Improving the performance of beef production systems in northern Australia

This document provides analyses of management strategies for beef production systems across three regions of northern Australia using the Breedcow and Dynama suite of programs. The document is an extension of the Breedcow and Dynama user manual and all files and spreadsheets used to undertake the analyses are available from the DAF website.

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Summary

The relative and absolute value of changing herd management strategy across key beef production regions of northern Australia was assessed using the Breedcow and Dynama programs and associated processes. In all cases, a change in the current herd management strategy was considered. That is, there was an investment and herd already in place and the analyses consider alternative management strategies that may improve the efficiency of the existing beef production system. The analysis was a marginal analysis, predominately over a uniform investment period of 30 years.

The alternative strategies were assessed for their potential impact on:

- the current wealth of the beef property (NPV);
- the average annual improvement (or reduction) in profit (Annualised return);
- 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)

The strategies were selected from production strategies identified by producers, industry and researchers over recent decades. Although the Breedcow and Dynama programs are capable of considering changes in management strategies such as different ways of financing the beef property, these other equally critical aspects of managing a beef property are not considered here.

The key insight gained from the analyses undertaken was that where a profitable beef production system was already in place it was difficult to find strategies that both improved profit <u>and</u> reduced the riskiness of that system. As the majority of analyses undertaken compared an existing investment in a relatively low-input, low-output operation with an alternative investment in a more intensive operation, the riskiness of the change was as critical a part of the assessment as the expected impact on profit of the change.

Even so, there is always room for fine tuning and the consideration of new technologies so we would recommend the process applied in this document as much as the results of the analyses. As identified by Makeham (1968), the two major challenges to the property manager remain:

- How to incorporate new technology profitably into their existing production system;
- How to be sufficiently flexible, mentally and financially, to adjust resource management to meet both changed economic circumstances and widely varying climatic conditions.

These challenges can be considered via the application of a comprehensive planning and assessment framework that applies the principles of Farm Management Economics. The Breedcow and Dynama program and associated processes facilitates the application of this framework for north Australian beef production systems.

Keeping in mind the constraints that apply to this form of analysis, the relationships in the following sections were found for a range of alternative management strategies available to change the performance of beef production systems in the respective regions.

Region 1 – Fitzroy catchment, Queensland

The results of the investigation of strategies for their ability to improve profitability and business resilience are summarised in Table 1.

Table 1 - Profitability and financial risk of implementing alternative strategies to improve profitability

Strategy	NPV of change	Annualised NPV	Peak deficit (with interest)	Years to peak deficit	Payback period (years)
Converting from weaner steers to bullocks	$822,777	$53,523	-$105,693	4	4
Improving steer performance					
Leucaena	$840,725	$54,690	-$465,728	6	12
Leucaena + purchased breeders	$910,120	$59,205	-$532,242	6	11
Other perennial legumes	$458,395	$29,819	-$436,067	7	14
Forage oats for feed on steers	-$539,079	-$35,068	-$1,482,018	never	never
Forage oats for bullocks	-$36,729	-$2,389	-$131,523	never	never
Feedlotting steers	-$1,085,730	-$70,628	-$2,988,831	never	never
HGP bullocks - same price, heavier weight	$30,529	$1,986	-$49,529	8	17
Improving breeder performance					
Production supplements for breeders	-$503,826	-$32,826	-$1,411,054	never	never
Better genetics for fertility					
Replace all bulls first year	-$50,196	-$3,265	-$126,309	never	never
Cull additional heifers as weaners	-$191,866	-$12,481	-$528,080	never	never
Lower starting weaning rate	-$48,857	-$3,178	-$131,101	never	never
Gradual replacement of bulls	$10,537	$685	-$898	6	9
Wet season spelling for breeders	-$21,375	-$1,715	-$56,715	never	never
Benefit of reducing foetal/calf loss in young females by 50%					
$5/head	$7,289	$474	-$1,829	5	6
$7.50 /head	-$6,427	-$418	-$17,502	never	never
$10/head	-$20,142	-$1,310	-$55,927	never	never
$20,000 capital	$15,672	$1,019	-$20,000	2	12
$30,000 capital	$6,148	$400	-$30,000	2	n/a
$40,000 capital	-3,376	-$220	-$40,451	4	never
Pestivirus, high prevalence, vac all	$15,750	$1,025	-$21,219	7	15
Pestivirus, high prevalence, vac heifers	$56,614	$3,683	-$3,276	6	6
Pestivirus, naïve herd vaccination	-$37,446	-$2,436	n/a	n/a	n/a
Inorganic supplements for breeders					
Marginal P herd, P wet season	$86,137	$5,603	-$7,185	3	3
Marginal P herd, N+P dry season	-$3,578	-$233	-$34,107	15	n/c
Marginal P herd, N+P dry, P wet	-$18,434	-$1,199	-$61,210	20	n/c
Deficient P herd, P wet season	$96,874	$6,302	-$26,907	3	3
Deficient P herd, N+P dry season	$56,247	$3,659	-$37,094	3	4
Deficient P herd, N+P dry, P wet	$36,655	$2,384	-$57,965	3	14
Acute P herd, P wet season	$695,035	$45,213	-$38,866	3	3
Acute P herd, N+P dry season	$435,778	$28,348	-$56,453	3	4
Acute P herd, N+P dry, P wet	$630,094	$40,989	-$87,535	3	4
Feeding first calf heifers	-$148,860	-$9,684	-$416,285	never	never
Marketing options					
Organic beef	$37,445	$2,436	n/a	n/a	n/a
EU slaughter and feed on	-$134,464	-$8,747	-$373,606	never	never
EU feed on only	-$123,566	-$8,038	-$339,795	never	never
Wagyu beef, price premium maintained	$506,411	$32,943	-$269,104	4	12
Wagyu beef, price premium reduces from year 20	$49,471	$3,218	-$269,104	4	n/a
Wagyu beef, price premium reduces from year 10	-$646,738	-$42,071	-$1,927,459	never	never

NPV is the net present value of an investment, referring to the net returns (income minus costs) over the 30-year life of the investment. **Marginal NPV** is the extra return added by the management strategy, i.e. it is the difference in profitability between the base, case study property and the same property after the management strategy was implemented. The annualised marginal NPV represents the average annual change in profit over 30 years, resulting from the management strategy. It is important to note that a negative marginal NPV does not necessarily indicate that a property implementing such a strategy is unprofitable, just that the strategy causes the business to be less profitable than the baseline scenario.

Peak deficit is the maximum difference in cash flow between the implemented strategy and the base scenario over the 30-year period of the analysis. It is a measure of riskiness.

Years to Peak Deficit identifies the number of years before the peak deficit was reached.

Payback period is the number of years it takes the cumulative present value to become positive. Other things being equal, the shorter the payback period, the more appealing the investment.

n/a: not applicable; n/c not calculable

The analysis indicates that a number of the alternative production strategies or technologies that could be applied to beef production systems in the Fitzroy region are unlikely to substantially improve resilience or add to profit. This is due to the representative, regional case-study property model already being an efficient beef production system with existing production targets well considered by beef producers for their impact on risk and profit.

For example, the available data for reproduction efficiency for the Fitzroy identifies a relatively high level of performance compared to other regions in northern Australia This reduces the economic benefit of marginal improvements in strategies like the genetic improvement of fertility and reducing pre-weaning calf loss. Higher cost strategies aimed at improving reproduction efficiency, such as providing energy rations to first calf heifers prior to calving, appear unlikely to ever be economic due to the changes in herd structure that occur when one component of an already efficient system is targeted in such a manner.

There are available strategies that target growth rates of the steer component of the herd that will improve efficiency and resilience as long as they are initially selected for their likely impact on profit at the property level. It is clear that the incorporation of perennial legumes, especially leucaena, into the diet of steers provides a substantial step forward in profitability and therefore resilience. Even so, the long payback periods for these perennial legume-grass pastures suggest that investments will have to be targeted closely with a staged development process applied to reduce the riskiness of the investment.

In contrast to the investment in perennial legumes, other strategies targeting steer nutrition reduced both the profitability and resilience of the beef production system. One strategy often used in the Fitzroy is to send steers to a feedlot to be custom fed and then slaughtered, either as a strategy to increase output or in preparation for drought. This action substantially reduced the profitability of the beef production system. Likewise, targeting the use of annual forages such as forage oats to increase steer growth rates has been shown in this analysis to be both a high risk and low profit venture. When considering a strategy of HGP use from weaning until sale producers need to ensure they will meet the specifications for the market they are targeting and need to consider effects on the overall herd structure if the age of steer turn-off changes. A small change in price or a change in the age of steer turn-off can make this strategy either profitable or unprofitable.

The one strategy that considered disease management in the breeder herd indicated that potentially high impact, episodic events, such as an outbreak of pestivirus in a naive breeder herd, are difficult to assess for their impact on profit and risk. This makes a recommendation of change to the current strategy (of no treatment) difficult to justify. Treatment of diseases that have an ongoing, low level of impact is also difficult to justify given the high cost of treatment and the difficulty of isolating and measuring the impact of treatment. Regional survey data indicates that producers are capable of assessing these risks within the context of the circumstances of their property when provided with adequate information about the risks of the disease and its aetiology. A decision not to prevent a disease can be equally as rational as taking action to prevent disease, depending upon the circumstances of the beef production system under threat.

Phosphorus deficiency is widespread across northern Australia and is a major constraint to the performance of beef cattle. In this analysis, we looked at the breeder herd in isolation and found that the value of providing supplements to reduce the impact of varying levels of P deficiency depended very much on the marginal benefits of providing an efficient supplementation program. Rigorous analysis of the existing level of P deficiency and its impact, the appropriate method of overcoming the deficiency and the value of fixing the deficiency need to be undertaken prior to implementation of any supplementation program. Breeder herds that are performing at the median level indicated in regional surveys (Adequate P status) are unlikely to show an economic response to any nutritional supplements whereas breeder herds running on country with an acute level of P deficiency are likely to show a strong economic response to appropriate levels of P supplementation. Breeder herds that run exclusively on Marginal P country appear likely to only show a measureable economic response to P supplements delivered in the wet season. For all herds with a measureable P deficiency, response to supplementation is likely to be much more profitable if delivered in the wet season only.

Strategies that target different markets such as the EU market for steers, organic production and Wagyu beef may offer short-term opportunities to improve profitability but also appear to increase risk due to the focus on a more narrow production system. Production systems that reduce flexibility over the longer term have been shown to be inherently more risky and therefore likely to expose the property to greater variation in returns.

Region 2 – Katherine region, Northern Territory

The results of the investigation of strategies for their ability to improve profitability and business resilience are summarised in Table 2.

Table 2 - Profitability and financial risk of implementing alternative strategies to improve profitability and resilience of beef enterprises in the Katherine region

Strategy	NPV of change	Annualised NPV	Peak deficit (with interest)	Years to peak deficit	Payback period (years)	IRR (%)
Improving herd performance						
Fixing a P deficiency	$5,106,316	$332,345	-$328,345	1	2	152
Herd Segregation $100,000 capital	$2,843,406	$184,968	-$100,000	1	1	235
Herd Segregation $500,000 capital	$2,462,454	$160,186	-$500,000	1	3	39
Herd Segregation $1,000,000 capital	$1,986,263	$129,209	-$1,000,000	1	7	19
Herd Segregation $2,000,000 capital	$1,033,882	$67,256	-$2,000,000	1	15	7.5
Home bred herd bulls	$424,620	$27,622	-$78,400	2	3	40
Improving breeder performance						
Cull more heifers before mating	-$703,386	-$45,756	-$1,969,428	never	never	n/c
Feeding first calf heifers	-$1,075,723	-$69,977	-$3,001,513	never	never	n/c
Feeding first calf heifers (half cost)	-$482,392	-$31,380	-$1,339,387	never	never	n/c
Better genetics for fertility						
Replace all bulls first year	$345,322	$22,464	-$225,425	5	15	9.4
Replace all bulls, pay more	$247,226	$16,082	-$356,882	5	19	5.3
Replace all bulls, lower conception	$165,219	$10,748	-$258,062	5	19	5
Gradual replacement of bulls	$712,184	$46,329	n/a	n/a	n/a	n/c
Gradual replacement, higher cost bulls	$401,482	$26,140	-$109,365	7	11	18.5
Benefit of reducing foetal/calf loss by 50%						
$5/head	$593,451	$38,605	-$26,575	1	1	162
$10 /head	$192,142	$12,449	-$87,635	4	9	19
$15/head	-$209,167	-$13,607	-$560,431	never	never	n/c
$100,000 capital	$899,522	$58,515	-$100,000	1	2	60
$200,000 capital	$804,284	$52,320	-$200,000	1	5	30
$400,000 capital	$613,806	$39,929	-$400,000	1	9	15.7
$800,000 capital	$232,855	$15,148	-$800,000	1	19	7.3
Benefit of reducing female mortality by 50%						
$5 per head	$979,326	$63,707	-$33,020	1	1	266
$10 per head	$477,289	$31,048	-$66,040	1	2	60
$20 per head	-$526,785	-$34,268	-$1,445,342	never	never	n/c
$100,000 capital	$1,386,125	$90,169	-$100,000	1	1	114
$500,000 capital	$1,005,173	$65,388	-$500,000	1	7	19.8
$750,000 capital	$767,078	$49,899	-$750,000	1	11	13
$1,250,000 capital	$290,887	$18,923	-$1,250,000	1	n/c	7
Improving steer performance						
Benefit of reducing steer mortality by 50%						
$5 per head	$471,420	$30,667	-$19,215	1	3	83.8
$10 per head	$168,885	$10,986	-$65,871	3	6	22.1
$20 per head	-$436,185	-$28,374	-$1,207,973	never	never	n/c
$50,000 capital	$726,337	$47,249	-$50,000	1	2	73.7
$100,000 capital	$678,717	$44,152	-$100,000	1	3	42.4
$500,000 capital	$297,765	$19,370	-$503,493	2	14	9.7
Stylo augmentation (1000 ha paddock)						
15% utilisation, May sale	$17,066	$1,110	-$116,654	4	n/c	2.7
15% utilisation, September sale	$122,482	$7,968	-$97,717	4	11	13.75
30% utilisation, May sale	$254,814	$16,576	-$189,841	4	11	14.27
30% utilisation, September sale	$473,571	$30,806	-$149,218	4	7	27.28
Stylo augmentation (all steers)	$2,282,461	$148,477	-$506,055	8	11	n/c
Feeding the steer tail concentrates	-$479,121	-$31,168	-$1,344,287	never	never	n/c
Feeding the steer tail concentrates high price	-$304,844	-$20,026	-$867,521	never	never	n/c
Agisting the steer tail on the floodplains	$915,695	$59,567	n/a	n/a	n/a	n/c
Agisting all steers on the floodplains	$1,783,765	$116,036	n/a	n/a	n/a	n/c

NPV is the net present value of an investment, referring to the net returns (income minus costs) over the 30-year life of the investment. **Marginal NPV** is the extra return added by the management strategy, i.e. it is the difference in profitability between the base, case study property and the same property after the management strategy was implemented. The annualised marginal NPV represents the average annual change in profit over 30 years, resulting from the management strategy.

Peak deficit is the maximum difference in cash flow between the implemented strategy and the base scenario over the 30-year period of the analysis. It is a measure of riskiness. **Years to Peak Deficit** identifies the number of years before the peak deficit was reached. **Payback period** is 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.

IRR is the internal rate of return on the marginal capital invested. This is the discount rate at which the present value of income from the investment equals the present value of total expenditure on the project, i.e. the break-even discount rate. This indicates the maximum interest that a project can pay for the project and break even.

The Katherine region of the Northern Territory can be characterised as having properties larger in size on average but generally with low output per unit area. The region has a long history of development being constrained by the availability of capital. The analysis identifies significant opportunities to increase both the productivity and level of production of beef systems in the region. Suitable investments aimed at improving beef production systems can be shown to add significantly to profit even at the long-term beef prices applied in this analysis. A common theme running through strategies such as herd segregation and fixing a P deficiency as well as the analysis of the value of reducing the rate of mortality in steers and breeding females is the level of impact on economic performance gained by efficiently reducing rates of mortality. Independent industry surveys have continued to identify high rates of mortality as a significant feature of beef production systems in this region and targeted investments that have an acceptable impact on average rates of mortality as well as other production parameters are likely to be sound investments.

Even so, the first investment that should be made in this region is in time to sort out the P status of the country grazed and the appropriate level of P supplementation. The data from the KSRS P supplementation trial confirms that appropriate P supplementation is the foundation of the profitability for many beef properties in this region. It is critical that the level of P deficiency of the beef herd on any property in this region is appropriately measured and treated - if this has not already been done.

The analysis of strategies that target the steer component of the herd provided some interesting insights. The feeding of high cost energy supplements to the steer weaner tail so they can be sold up to one year earlier is shown to be uneconomic, even at those times where steer prices are quite high and expected to fall. This effect is partly due to the high cost of the supplements and partly due to herd restructuring associated with selling steers at a younger age that produces proportionally more female beef that has a lower marginal value. The value of augmenting suitable land types with stylo pastures was shown to be highly dependent on the level of pasture utilisation assumed in the analysis, indicating a need for further research into how such pastures are appropriately managed. It is also obvious that further research is required into the potentially large benefits that could arise from placing steers on the floodplains during the dry season. This is a limited resource that could have a large impact on profit when appropriately utilised.

The strategy of focusing on improvement in reproduction efficiency through the genetic improvement of fertility looks to be underwhelming in its impact - even when what are considered to be favourable parameters are applied in the analysis. The extended period taken to gain benefits together with uncertainty about the level of benefits achievable suggest such a strategy would not be a priority for investment. Conversely, combining the genetic improvement strategy with a strategy of objectively selecting and breeding your own replacement herd bulls appears to present a way of addressing the genetic improvement of herd fertility in a cost effective manner. BYO bulls as a standalone strategy is also shown to have a quick and impressive return on the funds invested if the organisational skills and knowledge are available. Strategies that focus on supplementing cows or heifers with high cost energy supplements to improve reproduction efficiency are, as in other regions, shown to be more likely to reduce profit than increase it.

Region 3 – north Queensland Gulf

The results of the investigation of strategies for their ability to improve profitability and business resilience are summarised in Table 3.

Table 3 - Profitability and financial risk of implementing alternative strategies to improve profitability and resilience of beef enterprises in the north Queensland Gulf region

Scenario (Comparison is with land condition decline)	**Annualised marginal NPV**	**Peak deficit (with interest)**	**Year of peak deficit**	**Payback period (years)**	**IRR (%)**
Reducing cattle numbers and systematic wet season spelling to improve land condition (grazing land management)	$15,133	n/a	n/a	n/a	n/c
Grazing land management + adequate wet season P supplements	$59,764	n/a	n/a	n/a	n/c

Scenario (Comparison is with generally with +wet P, + land condition)	**Annualised marginal NPV**	**Peak deficit (with interest)**	**Year of peak deficit**	**Payback period (years)**	**IRR (%)**
Molasses production mix for steer tail	-$5,886	-$252,532	never	never	n/a
Increasing age of steer turnoff to 41 mths (cf. two cohorts at 26 and 37 mths)	$32,548	-$95,499	2	8	23.65
Stylo for steers (500 ha paddock)					
20% utilisation, May sale	$5,080	-$66,402	6	12	11.20
40% utilisation, May sale	$17,301	-$92,731	6	9	20.28
20% utilisation, September sale	$5,109	-$60,930	6	12	11.91
40% utilisation, September sale	$18,155	-$61.070	6	9	22.16
Stylo for all steers (property level)[A]					
20% utilisation, May sale	$31,011	-$270,595	9	15	10.02
P fertiliser on existing stylo (500 ha paddock)					
20% utilisation May sale	$12,682	-$70,636	2	6	21.71
20% utilisation, September sale	$11,001	-$60,909	2	6	22.13
20% utilisation, September sale + 10c/kg live	$12,889	-$59,842	2	5	24.94
Leucaena for steers (Frontage country, 500 ha paddock)[B]					
June sale	$54,606	-$464,193	5	10	16.18
October sale same price	$43,300	-$454,287	5	10	15.08
October sale + 10 c/kg live	$53,203	-$454,287	5	10	16.54
Feeding silage to home-bred steers	-$18,366	-$784,055	never	never	n/a
Sending steers on agistment	-$7,578	-$116,337	never	never	n/a
Genetic improvement of weaning rate					
Immediate changeover of bulls	$4,114	-$94,409	5	17	9.17
Gradual changeover of herd bulls	$6,761	n/a	n/a	n/a	n/a
Objectively selected home-bred bulls	$16,613	-$24,975	2	3	58.75
Supplementing first calf heifers	-$3,479	-$147,068	never	never	n/a
Reducing foetal/ calf loss by 50% by spending					
$5/breeder	$5,261	-$6,028	1	4	-
$7.50/breeder	$2,274	-$16,685	4	8	-
$10/breeder	-$712	-$36,946	never	never	-
$50,000 capital	$8,136	-$50,000	1	6	-
$75,000 capital	$6,588	-$75,000	1	9	-
$100,000 capital	$5,039	-$100,000	1	13	-

NPV is the net present value of an investment, referring to the net returns (income minus costs) over the 30-year life of the investment. **Marginal NPV** is the extra return added by the management strategy, i.e. it is the difference in profitability between the base, case study property and the same property after the management strategy is implemented. The annualised marginal NPV represents the average annual change in profit over 30 years, resulting from the management strategy.

Peak deficit is the maximum difference in cash flow between the implemented strategy and the base scenario over the 30-year period of the analysis. It is a measure of riskiness.

Payback period is 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.

IRR is the internal rate of return on the marginal capital invested. This is the discount rate at which the present value of income from the investment equals the present value of total expenditure on the project, i.e. the break-even discount rate. This indicates the maximum interest that a project can pay for the project and break even.

[A]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. All other strategies were compared to the new base property after 10 years of land condition improvement and adequate wet season P supplementation.

[B]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

Land condition decline across the northern Gulf region 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 case study property, was to address the decline in land condition 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.

Addressing these two issues for the case study property significantly improved relative profitability over the medium term but appeared unlikely to make the business sufficiently resilient to survive as a separate production system into the future. This was because profit 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 to address these two issues before considering anything else.

The remaining question was whether additional strategies could be found to make the property more viable. The results summarised in the lower part Table 3 are mostly for the difference in returns between the new case-study 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. Most of the pasture development scenarios were compiled at the paddock level.

Additional 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. The advantage provided by homebred bulls appears to arise from the high average value some producers pay for herd bulls and the difference between that cost and the costs associated with breeding your own. Planting leucaena on suitable land types also shows some promise but is unlikely to be widely applicable.

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 significantly improve business profit and resilience, even when achieved at a low cost. Strategies that involved improving the nutritional status of cattle by sending steers on agistment or providing expensive production supplements to steers or breeders always reduced profitability and resilience of the beef enterprise despite improving steer growth rates or breeder reproduction performance.

Table of contents

1 Objectives of the document

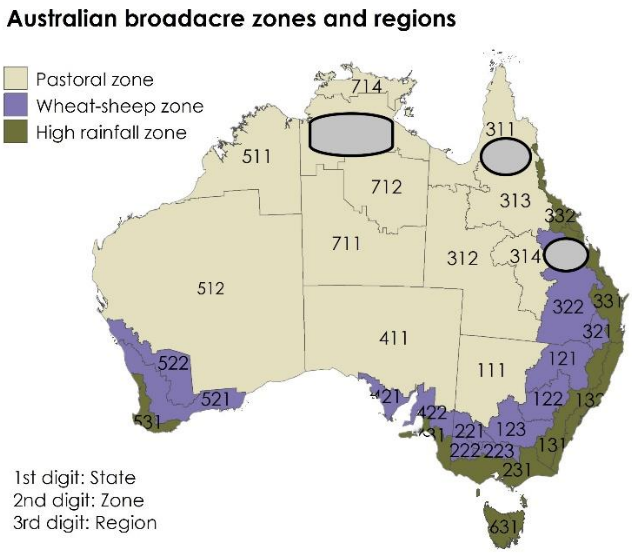
Beef producers need to apply an appropriate decision making framework when deciding which changes to their herd management are more likely to contribute to profitable and sustainable outcomes. This work aims to assist by:

- Using relevant research and other data to identify industry performance in selected production regions.
- Developing a representative herd and property model in each region that applies median industry performance.
- Applying an appropriate decision making framework to calculate the potential relative and absolute value of a range of strategies aimed at improving the performance of the beef production system.

1.1 Regions

Alternative management /investment strategies were tested across three different production regions. Figure 1 indicates the approximate location of the target regions.

Figure 1 Focus regions for production models



The regions are (north to south):

- The Katherine region of the Northern Territory.
- The northern gulf catchment of north Queensland,
- The Fitzroy catchment located in the Brigalow lands of central Queensland.

The Fitzroy represents a region with better than average land resources while the northern gulf catchments of Queensland represents a challenging region for beef production with generally smaller property sizes. The Katherine region of the Northern Territory also represents a challenging beef production region but has larger property sizes. These regions provide a snapshot of the relative and absolute value of alternative management strategies available to improve the performance of beef production systems across northern Australia.

2 Method

The Breedcow and Dynama programs were principally used to build representative models of a beef property based on available regional data. An assessment was then made of alternative ways of investing in or changing the management of the beef enterprise.

The economic and financial analyses undertaken consisted of a comparison of the current management system continued into the future, with an alternative system starting at the same point and also continued into the future. Change was implemented by altering the herd performance and inputs of a base case scenario so that a new scenario was constructed from the base case. The comparison of the two scenarios, one of which reflected the implementation phase and time taken to achieve the results of the proposed change from a common starting point, was the focus of the analysis.

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, optimal herd structure and 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 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 marginal 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 and the analysis undertaken at the property level. Additional detail and description of the Breedcow and Dynama suite of programs is provided by Holmes *et al*. (2017).

Discounted cash flow (DCF) techniques were applied and the economic criterions of choice were Net Present Value (NPV) at the required rate of return and the Internal Rate of Return (IRR). An investment of additional capital was not always identifiable when assessing strategies as they may have relied only upon a change in herd operation and/or a variation in treatment and labour costs.

This limited the capacity to calculate an IRR for the marginal return, and made the marginal NPV the criterion of choice when reporting the economic impact of change.

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 whole-of-business productivity and profitability over a 30-year investment period. 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 marginal returns associated with any additional capital or resources invested within farm operations. The DCF analysis was compiled in real (constant value) terms, with all variables expressed in terms of the price level of the present year. It was also assumed that future inflation would affect all costs and benefits even-handedly. The ongoing need for plant and equipment was captured by including an inventory of plant and equipment and profit was calculated net of an operator's allowance.

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 business. 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 was estimated by reference to what professional farm managers/overseers are paid to manage a similar property. Another fixed cost deducted in the calculation of 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 to extend their impact past 30 years in the form of an increase in closing land value. Scenarios were generally compared over a uniform 30-year investment period to account for the full economic life of the investment, the time taken to implement strategies, any changes in the timing of benefits or costs, the value of the resources required and any residual value of any resources applied. It is also necessary to compare investments over the same investment period when NPV is the criterion of choice.

Whilst every effort was made to ensure the assumptions used in each analysis were accurate and validated with industry participants, relevant experts or published scientific studies, the results presented should be viewed as indicative only.

2.1 Tax aspects

Many, if not all, of the scenarios analysed would have an impact on the tax liability of a beef property. The analyses concentrate on the profit and cash flow impact of a change in management strategy. The consideration of tax impacts is left to taxation experts.

Models developed to asses scenarios together with the past taxation records should provide sufficient information for a taxation expert to identify the impacts of change on tax liability. In some circumstances, the impacts on tax liability may be sufficiently large to change the investment decision. It is important to remember that remaining in the beef game is all about being sufficiently resilient over time to stay in the game. This is best done by focusing on profit first, then cash flow and then taxation.

2.2 The importance of applying the right analysis framework

The standard marginal analysis method of farm management economics using partial budgeting was applied here. This is the appropriate framework where an initial investment has been made and the concern is to increase profitability.

Key components of this framework are:

- The use of a marginal whole farm perspective instead of a discrete whole farm perspective.
- Investments are analysed over their expected life and the same investment period is applied to all comparable, alternative investments.
- All alternative investments start with a very similar level of capital investment in year zero, with changes in management implemented from year one,
- The management strategies are treated as mutually exclusive when ranked on NPV,
- The full profit or cash implications of any capital investments are captured.
- Cash (financial feasibility) and profit (economic efficiency) components are clearly distinguished.
- The time value of capital invested is incorporated.
- Livestock reconciliation /trading schedules appropriately incorporate livestock trading profits and losses.
- Nominal (or real) dollar values are consistently applied and not interchanged.
- Identification, where possible, of the relative riskiness of the alternative. As it is usual for the comparison to be between an investment in a relatively low-input, low-output operation and other more intensive operations, an assessment of the risks can be critical.

Marginal analysis was applied as partial discounted net cash flow budgets to define NPV at the required rate of return and the Internal Rate of Return. Such partial budgeting provides an estimate of the extra return on extra capital invested in developing the existing operation.

The proper perspective to bring to bear on the question of the potential profitability and efficiency of beef production systems based on pasture, where different ways of running a particular system are to be compared, is to apply partial budgets with the expected extra return on any extra capital invested to change the system as a critical criteria. It is also necessary to build a picture of the current operations before it is possible to identify whether a change will improve profit and/or reduce risk.

Adopting and implementing strategies to change production systems such as planting perennial legumes, feeding supplements, managing weaning, controlling mating, segregating herds, investing in infrastructure or other herd management strategies, warrant detailed consideration and whole of enterprise analysis. Intensification or extensification can be profitable, depending on the circumstances of the enterprise.

2.3 Using herd models to undertake a scenario analysis

The wide range of strategies available to improve the economic efficiency of northern beef properties together with the availability of viable off-farm investments makes it is necessary to explore both the relative and absolute value of investing to improve herd performance.

When applied as part of a planning process, the components of the Breedcow and Dynama software package provide a very useful framework for testing both the relative and absolute value of an investment or a change in herd management. The programs and herd models applied in the scenario analyses (and many example files) are available free at https://www.daf.qld.gov.au/animal-industries/beef/breedcow-and-dynama-software

2.4 The constraints that apply to scenario analysis when using nonspecific data

There are significant constraints when applying the broad understandings gained from modelling the performance of "typical" production systems to the circumstances of the individual property or herd. Opportunities for improvement are specific to properties and management systems, not necessarily to regions, production systems or land types. Scenario analysis based on data that is not specific to any property will often not be representative of the achievable outcomes for any property in particular. This is because each property has a different set of constraints and opportunities. The usefulness of any particular change in management or investment to an individual beef producer, therefore, completely depends upon the relative value of a change within their enterprise. That is, the *marginal* return on the investment needs to be assessed within the constraints of each particular beef enterprise considering change.

It needs to be clearly recognised:

- Key to success is the ability of management to apply an appropriate framework to assess the trade-offs, responses, costs and benefits likely from the implementation of any opportunity for their property under their circumstances.
- The ultimate decision criteria to judge a potential change to a beef enterprise is the extra return on extra capital invested (marginal return) that is likely to result, weighed up in the context of the extra risk – both enterprise risk and financial risk - associated with the change.
- Applying an appropriate framework to decision making and understanding the reasoning behind the process will point roughly which direction to go, not the "answer".
- Opportunities for improving enterprise performance are specific to the unique resources, management system and managers of each property. This means that an investment that improves the performance of property A may or may not improve the performance of property B even though they are both found in the same region and have similar production characteristics.
- The investment analyses undertaken relied on the application of the results of research and industry surveys to regional / average production systems. Therefore, the results of the analyses may not be representative of the achievable outcomes for any property in

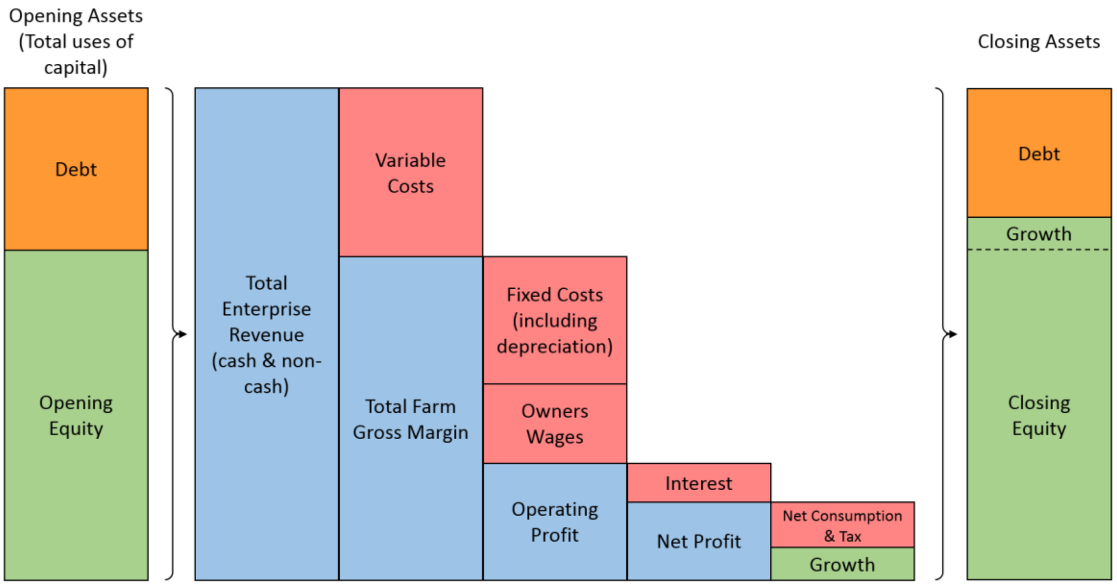
particular. They identify the potential economic value of the level of response found by researchers looking at various technologies, strategies or levels of industry performance.

3 The role of profit in building resilience

Beef production systems confront many risks and great uncertainty. Risks are things that you know will occur, just unsure when– there is going to be another drought, another flood. Uncertainties are things that cannot easily be predicted – such as the sudden closure of an important export market – Japan in the 1970's, Indonesia in the 2010's. Both risk and uncertainty combine to make decisions to change challenging.

To stay in beef production – and to cope with the risks and uncertainties - there is a need to be profitable and to continue to build equity. Figure 2 shows the direct link between profit and growth in equity. Building equity is the foundation of building resilience in a beef business.

Figure 2 - Link between profit and growth (Malcolm et al. 2005)



Although the profit motive rarely drives beef producers to do what they do, a beef production system needs to regularly produce profit. Growth in equity is the buffer that allows risks and uncertainties to be managed when they have impact.

Building equity usually means change has to be considered and investments have to be made. Any framework applied to assess the value of change must focus on:

- the extra (marginal) costs, the extra (marginal) returns (= the change in profit);
- the risks associated with change, and
- the timing of the extra costs and extra returns.

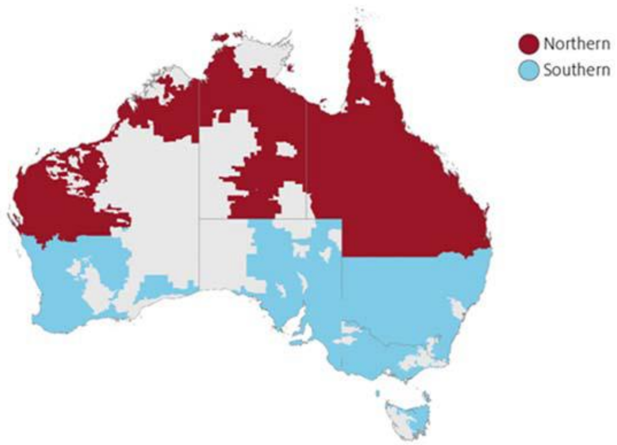
4 Background to the northern Australian beef cattle industry

The beef cattle industry makes an important contribution to the Australian economy. In 2014– 15 it accounted for around 21 per cent ($11.5 billion) of the total gross value of farm production and around 23 per cent of the total value of farm exports income (ABARES 2016).

From 2012–13 to 2015–16 the beef cattle herd declined by around 10 per cent to an estimated 23.3 million head. This decline resulted from high cattle turn-off because of prolonged poor seasonal conditions and, more latterly, strong export demand (Mullumby, Whitnall & Perndt 2016).

The industry is broadly divided into two production regions, Northern and Southern. The Northern region is defined as all of Queensland and the Northern Territory as well as northern Western Australia. The remainder of Australia, including southern Western Australia, South Australia, New South Wales, Victoria and Tasmania, make up the Southern region (Figure 3).

Figure 3 Beef production regions



Northern Australia and southern Australia have marked differences in climate, pastures, industry infrastructure and proximity to markets. This has affected the development and nature of the beef industry and associated farm enterprises in each region.

The beef cattle industry in northern Australia focuses primarily on beef export markets and on the live cattle export trade. In contrast, production in the southern states is spread more evenly between the beef export market and the domestic beef market (Gleeson, Martin & Mifsud 2012).

Rainfall in northern Australia is dominated by monsoon systems that create a wetter season (usually November to March) and a drier season (usually April to October). This limits the growing season for pastures and, unlike southern Australia, makes it difficult to finish cattle for markets in one production year. Rainfall is not uniform. The intensity and duration of wet and dry seasons varies depending on latitude, topography and distance from the coast.

A more variable quantity and lower quality of pasture in most northern areas results in lower stocking rates and more extensive production systems than in southern Australia, on average.

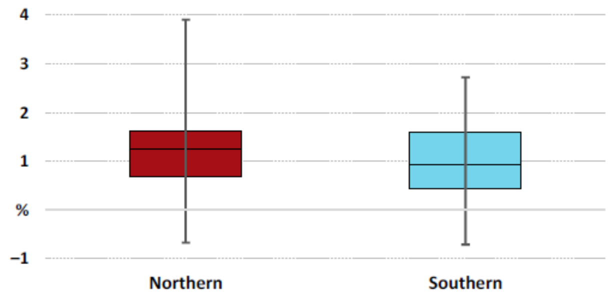
In the three years ending 2013–14, northern Australia had more than 8 500 beef cattle producing farms. Around 97 per cent of these farm enterprises were in Queensland, 2 per cent in the Northern Territory and 1 per cent in Western Australia. (Martin 2015)

Australian Agricultural and Grazing Industries Survey (AAGIS) data indicate:

- Branding rates in northern Australia averaged 71 per cent for the 10 years ending 2013–14, compared with 86 per cent in southern Australia
- Turn-off rates (cattle sold or transferred off-farm as a percentage of the average herd size) averaged 33 per cent in northern Australia for the 10 years ending 2013–14, compared with 44 per cent in southern Australia

The long term performance of farm enterprises is determined by both the level and variability of profit. Figure 4 summarises variation in the rate of return on capital (excluding capital appreciation) for the period 2000–01 to 2015–16. Figure 4 shows some difference in variation between regions, with Northern region farms generating a relatively wide range of returns over the past 16 years. However, Figure 4 also reveals that, while beef farms in the Northern region experienced the greatest overall variation in returns over this period, very low and negative rates of return occurred no more often than in the Southern region. (Ashton et al 2016)

Figure 4 Rate of return variability by region, 2000–01 to 2015–16 (Source: ABARES Australian Agricultural and Grazing Industries Survey)



Productivity is an important measure of performance for Australian agriculture because it reflects improvements in the efficiency with which inputs such as land, labour and capital are used to produce outputs such as meat, crops, wool and milk. Productivity growth is important for maintaining international competitiveness and profitability given long-term declines in Australian farmers' terms of trade.

Productivity growth is defined as an increase in output beyond any associated increase in input (or a decrease in the quantity of inputs needed to produce a unit of output). Most of the productivity gains in the beef industry between 1977–78 and 2013–14 were made in the Northern region (Table 4). Productivity growth in this region averaged 1.5 per cent a year, driven by output growth of 1.1 per cent a year and reduced input use of 0.4 per cent a year.

Table 4 Average annual beef industry TFP growth, by region, 1977–78 to 2013–14 (ABARES 2016)

Beef farms	Input growth %	Output growth %	TFP growth %
All beef farms	–0.2	1.1	1.3
Southern region	0.5	1.2	0.6
Northern region	–0.4	1.1	1.5

Ashton et al (2016) attribute this improvement in productivity to:

- greater use over time of climate appropriate Bos indicus breeds
- improved reproductive performance and reduced death rates resulting from the brucellosis and tuberculosis eradication campaign of the 1980s which allowed managers to cull poorly performing stock and invest significantly in fences, on-farm infrastructure and cattle management systems,

- expansion of the feedlot sector and the live export trade during the 1990s,

Exclusion of the smallest beef farms (farms with less than $200,000 in farm receipts) results in the estimate of beef industry productivity rising to average 2.0 per cent a year, a higher rate of productivity growth than the 1.5 per cent estimated for grain growing farms from 1977–78 to 2012–13. (Martin 2015)

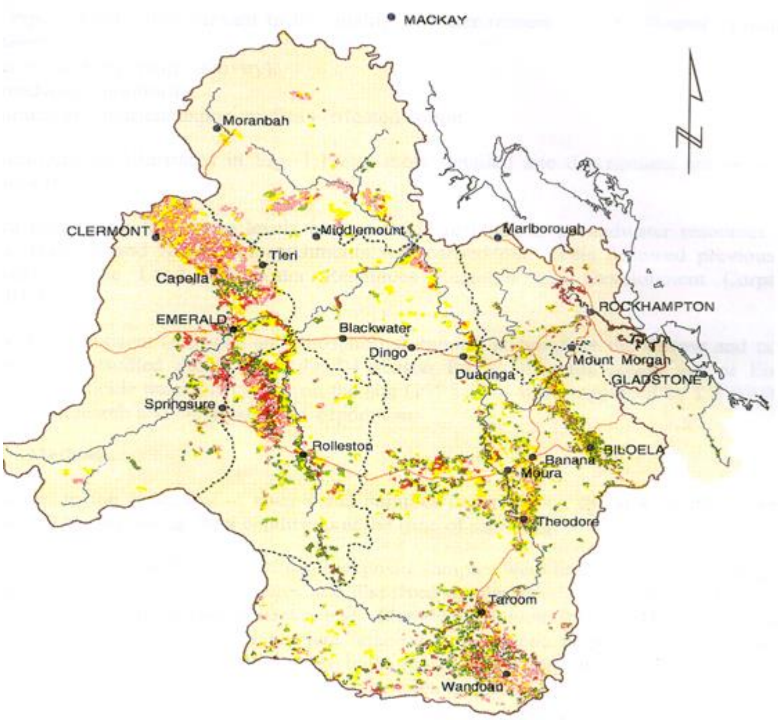
The northern beef industry has expanded over the past 20 years, driven partly by growth in the live export trade. Since 1988–89 average herd size has increased at an average rate of 1.3 per cent a year and stocking rates have increased by 2 per cent a year on average. (Martin et al 2013)

The northern Australian beef industry, although identified by some (McCosker et al 2009, McLean et al 2014) as having poor performance, has shown significant growth and high levels of improvement in efficiency over many decades. The sector is a major contributor to the economic growth and stability of regional communities across northern Australia. Even so, the future is likely to be equally as interesting as the past and industry participants need to continue to focus on productivity growth through implementing change that improves profitability.

5 Region 1: The Fitzroy catchment

5.1 Location and climate

Figure 5 Fitzroy catchment (DNR Qld 2002) showing cultivated land in red and green



The Fitzroy River catchment is characterised by a sub-tropical, semi-arid climate with high rainfall variability. The amount and distribution of rainfall are primary determinants of pasture and forage growth. Temperature can also be a constraint to growth for some crop and pasture species.

Annual rainfall decreases with distance from the coast. The ratio of summer to winter rainfall decreases from north to south, with an average ratio of 70:30. Mean maximum and mean minimum temperatures decrease from north to south with mean daily maxima over 33 °C in January. Frosts occur regularly throughout the region but become more frequent and severe towards the south. For example, Brigalow Research Station near Theodore averages 12.3 frosts (days with ground temperature ≤ −1 °C) annually, whereas Taroom averages 18.2 frosts annually.

Beef production is the major land use in the Fitzroy River catchment, occurring on around 12.3 million hectares or approximately 85% of the catchment and with cattle production accounting for 66% of the total value of agricultural production (ABS 2014 a, b).

Large areas of fertile soils suitable for cultivation, improved pastures and generally more reliable rainfall have encouraged diverse beef production systems ranging from weaner and store steer systems through to systems to finish or background cattle on high output forages such as forage oats and leucaena. Backgrounding is a process used to prepare stock for feedlot entry.

Barbi et al (2015) summarise a beef industry survey undertaken between 2011 and 2014 in the reef catchments to record grazing management practices. Table 5 shows the values identified for beef herds in the Fitzroy catchment.

Table 5 Herd characteristics Fitzroy catchment

Factor	Value
Median property area (ha)	7,100
Median herd size (head of cattle)	1,800
Percentage of enterprises with breeding herd	85%
Enterprises where cattle are largely sold direct to abattoir	56%
Enterprises where cattle are largely sold as stores	29%
Target Jap Ox production with steers	55%
Target domestic market with surplus heifers	62%
Target American market with surplus cows	81%
Carcase weight of steers sent to abattoirs	346 kg
Carcase weight of heifers sent to abattoirs	278 kg
Carcase weight of cull cows sent to abattoirs	315 kg
Age in months slaughter steers	31
Percentage female sales	44%
Percentage male sales	56%
Average annual sales of males (number)	503
Average annual sales of females (number)	292
Weaning weight range (poor season to good season)	166 to 221 kg
Weaning percentage – replacement heifers	77%(2011) 80% (2012)
Weaning percentage – first calf heifers	70%(2011) 70% (2012)
Weaning percentage – breeders	84%(2011) 85% (2012)
Weaning percentage – breeders not segregated by age	80%(2011) 85% (2012)
Percentage enterprises who segregate heifers	80%
Percentage heifers first joined > 18 months	50%
Continuous mating - mature breeders	32%
Continuous mating - maiden heifers	25%
Continuous mating - first lactation heifers	32%
Pregnancy testing not used	17%
Bull soundness examination used	61%
Bull joining percentage	3.2%
Use of EBV's when selecting bulls	42%
Health treatment weaners – botulism	16%
Health treatment weaners – 5 in 1	53%
Health treatment weaners – 7 in 1	26%
Health treatment weaners – Leptospirosis	5%
Health treatment weaners – Pestivirus	3%
Health treatment weaners – Tick fever	28%
Vibriosis for bulls	35%
3 day fever for bulls	17%
Supplements fed	94%
Supplement cost	$17 per head
Foetal aging used for management	17%
Individual animal data recorded	46%
Number of times stock handled per annum	4-5

For the Fitzroy, they found a median property area of 7,100 hectares and a median beef herd size of 1,800 head. 85% of the surveyed properties had a breeding herd and 56% of total enterprises sold the majority of their output direct to the meatworks. 29% of properties mostly sold stores.

Target slaughter markets were heavyweight grass fed steers (55% of respondents), the domestic market with surplus heifers (62% respondents) and the American market with surplus cows (81% of respondents). Target sale weights for stock sent to the abattoirs were 346 kilograms dressed for steers; 278 kilograms dressed for heifers and 315 kilograms dressed for cows.

A weaning weight range (poor season to good season) of 166 to 221 kilograms live weight was found with a range of weaning percentages depending upon the seasonal conditions - replacement heifers 77% to 80%; first calf heifers ~70%; and breeders 80% to 85%.

Most respondents (80%) segregated their heifers with 50% first joining heifers at 18 months of age. Many producers (~70%) removed bulls from the breeding herd for part of the year and most (>80%) used pregnancy testing as a herd management tool. About 17% of respondents also applied foetal aging as a herd management tool. A smaller percentage of respondents (61%) applied bull soundness examinations as a management tool with a smaller proportion again (42%) using EBV's when selecting bulls. The average bull joining percentage was calculated as 3.2%.

Health treatments applied to weaners varied. 16% treated to prevent botulism; 53% applied 5 in 1 vaccine; 26% applied 7 in 1 vaccine; 5% vaccinated for leptospirosis; 3% for pestivirus and 28% for tick fever. 35% of respondents inoculated herd bulls to prevent vibriosis and 17% inoculated herd bulls for 3 day fever. Most (94%) fed supplements of some form and incurred an average supplement cost $17 per head. Almost half (46%) of respondents recorded data for individual animals with stock handled four to five times per annum on average.

5.2 Representative beef property details

5.2.1 The property

The hypothetical property is located centrally in the region with a number of selling centres and abattoirs available for sale stock. Detailed price data over time is available for the Roma stock selling centre (about 380 kilometres) and Dinmore abattoirs (about 650 kilometres). As both centres are relevant indicators of market prices for beef producers in the region, these two selling centres were used to calculate net sale values. Transport costs to other selling centres may be lower but net sale values are similar. The property has a total area of 8700 hectares and carries about 1500 adult equivalents.

5.2.2 Beef production activity

The modelled activity was a self-replacing breeding and growing activity that relies on the production of weaners by a breeding herd. Weaner steers enter a growing system that varied in size with the period of time steers were retained prior to sale. Weaner heifers were used to maintain the breeding herd or were culled and sold. Replacement heifers were separated from the breeding herd until they were first mated at about 2 years of age. Breeding cows were culled on reproduction performance and age. Herd bulls were retained in the breeding herd for an average of five years. Cull herd bulls and the majority of cull cows were sold to the abattoirs. Steers and surplus heifers have a variety of marketing opportunities although the current plan was to principally sell 2 to 3 year old steers, cull bulls and cull cows to the abattoirs.

5.2.3 Steer and heifer growth model

The pattern of growth over time for steers and heifer underpins the markets available for both steers and surplus heifers and the likely mating age and reproduction performance of the heifers as they enter the breeding herd. Bowen et al (2105a, 2017) described the expected growth of steers grazing improved grass pastures in the Fitzroy catchment. Table 6 shows the expected "average" birthdate and weaning date plus the pre weaning performance of the steers and heifers on the property.

Table 6 Birthdate, weaning date and pre weaning performance

Factor	Value	
Average calving date	15/11/2018	
Birth weight	35	kg
Average weaning date	15/05/2019	

Age at weaning	6.0	months
Days to weaning	181	days
Male calf average daily gain birth to weaning	0.9	kilograms / day
Reduction in growth rate compared to steers	5%	
Heifer average daily gain birth to weaning	0.86	kilograms / day

Table 7 indicates the expected post weaning seasonal performance for steers. Steers were assumed to gain weight at about 0.49 kg/head/day on buffel grass pastures to achieve 180 kg/head/annum post weaning and heifers to gain ca. 0.47 kg/head/day to achieve 171 kg/head /annum post weaning.

Table 7 Expected post weaning steer growth rates

Season	Days	Daily liveweight gain (kg/d)	Total liveweight gain (kg)
Summer (D-J-F)	90	0.80	72
Autumn (M-A-M)	92	0.73	67
Winter (J-J-A)	92	0.35	32
Spring (S-O-N)	91	0.10	9
Average/Annual	*365*	*0.49*	*180*

The data in Table 7 was used to identify when steers and heifers were likely to reach suitable sale weights for different markets or mating weights. Table 8 shows the liveweight by months of age, expected sale weights and sale months.

Table 8 Expected liveweight by months of age for steers and heifers

Cumulative months from birth	Date calculation	Month	Expected steer weight gain per day	Steer growth path Birth weight	Expected Heifer weight gain per day	Heifer growth path Birth weight	Average For AECalc
0	15/11/18	Nov		35		35	
1	15/12/18	Dec	0.90	62	0.86	61	
2	15/01/19	Jan	0.90	90	0.86	87	
3	15/02/19	Feb	0.90	118	0.86	114	
4	15/03/19	Mar	0.90	143	0.86	138	
5	15/04/19	Apr	0.90	171	0.86	164	168
6	15/05/19	May	0.90	198	0.86	190	194
7	15/06/19	Jun	0.35	209	0.33	200	
8	15/07/19	Jul	0.35	219	0.33	210	
9	15/08/19	Aug	0.35	230	0.33	220	
10	15/09/19	Sep	0.1	233	0.10	223	
11	15/10/19	Oct	0.1	236	0.10	226	
12	15/11/19	Nov	0.1	239	0.10	229	234
13	15/12/19	Dec	0.8	263	0.76	252	
14	15/01/20	Jan	0.8	288	0.76	275	
15	15/02/20	Feb	0.8	313	0.76	299	
16	14/03/20	Mar	0.73	333	0.69	318	
17	14/04/20	Apr	0.73	356	0.69	340	
18	14/05/20	May	0.73	378	0.69	361	
19	14/06/20	Jun	0.35	389	0.33	371	
20	14/07/20	Jul	0.35	399	0.33	381	
21	14/08/20	Aug	0.35	410	0.33	391	
22	14/09/20	Sep	0.1	413	0.10	394	
23	14/10/20	Oct	0.1	416	0.10	397	
24	14/11/20	Nov	0.1	419	0.10	400	
25	14/12/20	Dec	0.8	443	0.76	423	
26	14/01/21	Jan	0.8	468	0.76	446	
27	14/02/21	Feb	0.8	493	0.76	470	
28	14/03/21	Mar	0.73	513	0.69	489	
29	14/04/21	Apr	0.73	536	0.69	511	
30	14/05/21	May	0.73	558	0.69	532	
31	14/06/21	Jun	0.35	569	0.33	542	
32	14/07/21	Jul	0.35	579	0.33	552	
33	14/08/21	Aug	0.35	590	0.33	562	

34	14/09/21	Sep	0.1	593	0.10	565	
35	14/10/21	Oct	0.1	596	0.10	568	
36	14/11/21	Nov	0.1	599	0.10	571	
37	14/12/21	Dec	0.8	623			
38	14/01/22	Jan	0.8	648			
39	14/02/22	Feb	0.8	673			
40	14/03/22	Mar	0.73	693			
41	14/04/22	Apr	0.73	716			
42	14/05/22	May	0.73	738			
43	14/06/22	Jun	0.35	749			
44	14/07/22	Jul	0.35	759			
45	14/08/22	Aug	0.35	770			
46	14/09/22	Sep	0.1	773			
47	14/10/22	Oct	0.1	776			
48	14/11/22	Nov	0.1	779			

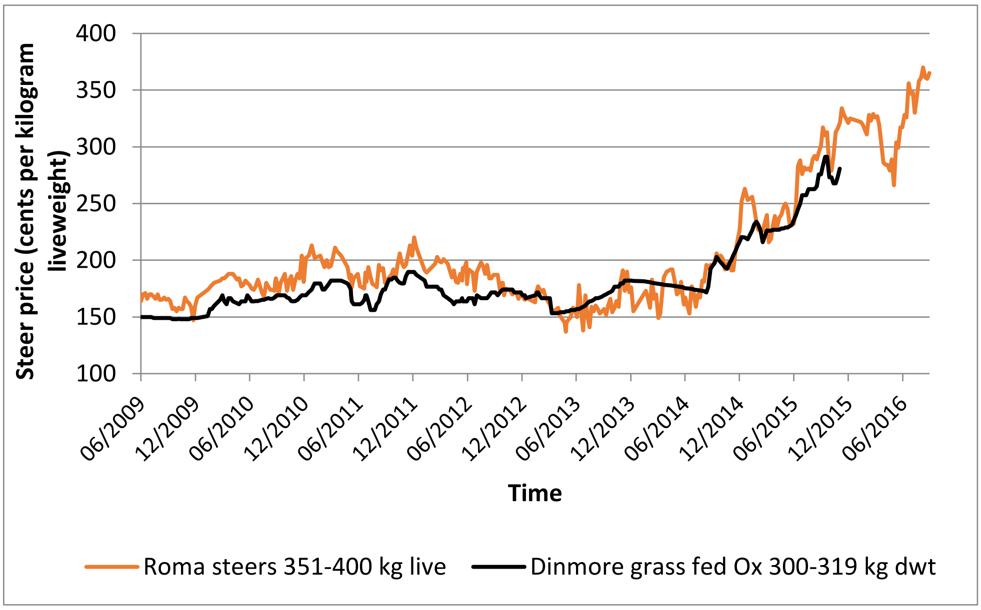
This steer and heifer growth model underpinned the growth performance for the modelled property. Although a relatively large amount of variation in growth rates is expected over time and between paddocks, we used average growth rates of 180 kg/head/annum for steers and 171 kg/head/annum for heifers post weaning where each class had access to the same level of nutrition.

The wide range of markets available to beef producers in the Fitzroy catchment indicates that steers and surplus heifers can be sold at almost any point along the growth path although not all points are expected to produce equal profit for the property.

5.2.4 Prices

Figure 6 shows the relationship over recent years between the prices of medium sized store steers at Roma and grass fed Jap Ox at Dinmore since mid-2009. Prices for most classes of cattle have risen dramatically over recent times.

Figure 6 Steer prices over time



Roma store sales and Dinmore abattoir have summarised price data available by sale class. This is the main reason these selling centres where chosen. Roma store sale data will be used to estimate the values of store stock classes and Dinmore prices will be used to estimate slaughter prices. Selling costs relate to the selling centre chosen. Table 9 shows price data for Dinmore abattoirs.

Table 9 Price ranges for Dinmore abattoir (July 2008 – November 2015)

	Grass Fed Jap Ox	Grass Fed Jap Heifer	Cow	Bull
Grade	**J**	**I1**	**L/M/M9**	**Q**
Weight (kg)	**300-319**	**200-219**	**220-239**	**320-499**
Teeth	**0-6**	**0-4**	**8**	**0-8**
Fat (mm)	**5-22**	**5-22**	**3-12**	**0-32**
	$/kg dwt	**$/kg dwt**	**$/kg dwt**	**$/kg dwt**
Mean	3.59	3.29	3.22	3.18
Median	3.30	3.00	2.92	2.95
Max	5.60	5.35	5.30	5.10
Min	2.85	2.45	2.35	2.25
Dressing %	52%	52%	50%	52%
Cents / kg live equivalent	$1.87	$1.71	$1.61	$1.65

The average price for Ox at Dinmore since 2004 is about $3.46 per kg dressed weight (dwt) or $1.80 when expressed on an equivalent liveweight basis at a 52% dressing percentage (data not shown).

The same class of stock averaged $1.87 on a liveweight basis from July 2008 to November 2015. Seven cents a kilo liveweight can make a significant difference to economic and financial outputs when comparing various sale strategies. Table 10 indicates the price variation for sale weights for steers and heifers at the Roma store sale between 2008 and 2015. Prices are shown as cents per kilogram liveweight. The average size of the yarding indicates Roma is a major selling centre for store cattle.

Table 10 Price ranges at Roma sale yards (July 2008- November 2015) expressed as cents per kilograms liveweight

	Yarding	**Steers**					**Heifers**
Live weight range	**(Kg)**	**<220**	**221-280**	**281-350**	**351-400**	**401-550**	**281-350**
Mean	6,995	205	204	196	190	189	169
Median	6,997	199	197	189	181	178	164
Max	12,242	370	355	341	334	320	316
Min	1,547	136	142	136	137	137	106

In this analysis the average of the values (July 2008-November 2015) were applied to reflect the expected real average for prices into the future. Not all of the recent price spike was included in the average as its long term effect on prices is unknown. Table 11 shows the price data and selling costs for each class of stock retained in the herd models.

Table 11 Sale weights, selling prices, selling costs, gross and net values

Group Description:	**Paddock Weight Kg/head**	**Weight loss to sale**	**Sale weight Kg/head**	**Price $/kg**	**Commission % of Value**	**Other selling $/head**	**Freight $/head**	**Gross Price**	**Total Selling & Freight Costs**
Heifer weaners	194	5%	184	$1.76	4.00%	$17.00	$18.05	$324.37	$48.02
Heifers 1 year	361	5%	343	$1.69	4.00%	$17.00	$24.07	$579.59	$64.25
Heifers 2 years	532	5%	505	$1.71	0.00%	$5.00	$53.70	$864.23	$58.70
Cows 3 years	520	5%	494	$1.61	0.00%	$5.00	$53.70	$795.34	$58.70
Steer weaners	194	5%	184	$2.05	4.00%	$17.00	$18.05	$377.82	$50.16
Steers 1 year	378	5%	359	$1.90	4.00%	$17.00	$25.79	$682.29	$70.08
Steers 2 years	493	5%	468	$1.89	4.00%	$17.00	$30.08	$885.18	$70.49
Steers 3 years	738	5%	701	$1.87	0.00%	$5.00	$77.19	$1,311.06	$82.19
Cull bulls	750	5%	713	$1.65	0.00%	$5.00	$77.19	$1,175.63	$82.19

An allowance for 5% weight loss was made between the paddock weights and the sale weights. The expected selling costs of each class of stock varied due to whether they were sold in Roma or at Dinmore. Table 12 shows the expected transport costs per head for each potential class of sale cattle.

Table 12 Transport cost calculations

	Weaners	Heifers 12-24 m	Heifers 24-36 m	Cows	Steers 12-24 m	Steers 24-36m	Steers 36-48m	Bulls
Transport cost $/deck/km	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
Distance (km)	380	380	650	650	380	380	650	650
Number of head /deck	40	30	23	23	28	24	16	16
Freight cost/head	$18.05	$24.07	$53.70	$53.70	$25.79	$30.08	$77.19	$77.19

5.2.5 Husbandry costs and treatments

Table 13 shows the treatments applied to the various classes of cattle held for twelve months in the model. Sale stock may or may not have received the treatment depending upon the timing of sale.

Table 13 Treatments applied and cost per head

	Weaners	Females 1-2 years	Females 2-3 years	Females 3 years +	Steers	Bulls
Weaner feed	$15					
NLIS tag	$3.5	$0.20	$0.20	$0.20	$0.20	$0.20
5 in 1 calves	$0.80					
Leptospirosis vaccine breeders		$2.34	$1.17	$1.17		
Tick treatment	$4	$6	$10	$10	$6-$10	$10
Vibrio vaccine bulls						$10
Drought feeding (1 year in 7)		$5	$6	$7.5		$10
Pregnancy testing		$5	$5	$5		

5.2.6 Other herd performance parameters

Data to describe the reproduction efficiency of the breeder herd was based on the data collected by the Cash Cow project (McGowan et al 2014). The median values for the region the Cash Cow project termed Central Forest are summarised in Table 14. This data set is seen as being closest to the expected median performance of a beef breeding herd in the Fitzroy catchment.

Table 14 Median reproduction performance for Central Forest data (McGowan et al 2014)

	Heifers	First lactation cows	2nd lactation cows	Mature	Aged	Overall
P4M*		49%	64%	77%	71%	68%
Annual pregnancy**	80%	78%		89%	86%	85%
Foetal / calf loss	10.20%	7.30%		5.90%	4.90%	6.70%
Contributed a weaner^	67%	71%		80%	86%	77%
Pregnant missing#		11.80%		6.60%	6.30%	7.90%

*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

Placing the Cash Cow data for reproductive efficiency and estimates median mortality rates in a herd model produces a weaning rate 77% (from cows mated). Table 15 shows the level of reproductive performance of each class of females required to achieve an average weaning rate of 77.6% for all cows mated in the Breedcowplus model. The values retained produced a weaning rate equivalent to

CashCow's 'contributed a weaner' figure of 77% while maintaining a strong relationship to the annual pregnancy (conception), calf loss and missing data provided by the CashCow project.

Table 15 Calving rate and death rate assumptions

Cattle age year start Cattle age year end	Weaners 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9
Expected conception (%)	n/a	0	80	78	87	87	87	87	84
Expected calf loss from conception to weaning (%)	n/a	0	10	7	6	6	6	6	5
Proportion of empties (PTE) sold (%)	n/a	0	100	100	100	100	100	100	100
Proportion of females sold (%)	n/a	0	0	0	0	0	0	0	0
Calves weaned/cows retained (%)	n/a	0	90	93	94	94	94	94	95
Female death rate (%)	3	3	5	4.	4	4	4	4	5.5
Male death rate (%)	4	4	4	4	n/a	n/a	n/a	n/a	n/a

n/a: not applicable.
PTE, pregnancy tested 'empty'.

The culling strategy for the baseline herd removed cows that did not show as pregnant after mating or after they had produced a calf at 12-13 years old. The mortality rates are based on the CashCow project data for missing pregnant females and reflect the mortality data analysed by Henderson *et al.* (2012) for the northern beef industry. Although data from Henderson *et al.* (2012) was not collected from the Fitzroy region, the mortality rates applied in the Breedcowplus herd model are a seen as a balance between the CashCow estimates of missing pregnant females and the values identified by Henderson *et al*. (2012) for steers and breeding females.

5.2.7 Herd structure and gross margin "without change"

The compiled herd model resulted in average breeder mortality rates of 4.53% and a weaning rate of 77.6% (weaners from all cows mated). The property produced about 433 weaners from the 558 females mated and sold 382 head per annum. Cull female sales made up 49.5% of total sales. Table 16 shows the average herd structure of the baseline beef cattle enterprise.

Table 16 - Herd structure (on average)

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	151
Weaners 5 months	350	83	0.26	0.07	96
Heifers 1 year but less than 2	129	0	0.69	0.32	89
Heifers 2 years but less than 3	100	25	1.07	0.51	120
Cows 3 years plus	364	79	1.21	0.69	570
Steers 1 year but less than 2	208	0	0.72	0.34	150
Steers 2 years but less than 3	199	0	1.12	0.25	223
Bullocks 3 years but less than 4		191	1.51	0.73	141
Bulls all ages	20	3	1.65	0.96	35
Total number.	*1,370*	*444*	-	-	*1,500*

AE, Adult equivalent. A 2.25 year old, 450 kg steer at maintenance.
n/a, not applicable.

The combination of reproductive efficiency, mortality rates, growth rates, treatment costs and selling costs provided the performance parameters and gross margin for the starting herd shown in Table 17.

Table 17 Herd parameters and gross margin for the baseline property

Parameter	Starting herd
Total adult equivalents	1500
Total cattle carried	1370

Weaner heifers retained	133
Total breeders mated	558
Total breeders mated & kept	465
Total calves weaned	433
Weaners/total cows mated	77.60%
Weaners/cows mated and kept	93.19%
Overall breeder deaths	4.53%
Female sales/total sales %	49.48%
Total cows and heifers sold	188
Maximum cow culling age	13
Heifer joining age	2
Weaner heifer sale & spay	38.48%
One year old heifer sales %	0.00%
Two year old heifer sales %	20.00%
Total steers & bullocks sold	191
Max bullock turnoff age	3
Average female price	$541.43
Average steer/bullock price	$1,228.87
Capital value of herd	$876,749
Imputed interest on herd value	$43,837
Net cattle sales	$336,830
Direct costs excluding bulls	$27,463
Bull replacement	$16,108
Gross margin for herd	$293,145
GM after imputed interest	$249,308

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

5.2.8 Investment returns

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

Table 18 Fixed cash costs

Item	Cost
Accountant	$5,000
Administration	$2,000
Bank Charges other than interest	$500
Blade Ploughing	$10,000
Casual Labour	$0
Electricity - Farm	$5,000
Farm Rates	$9,500
Fuel and Oil	$25,000
Insurance - Farm	$4,500
Motor Vehicle Expenses	$3,000
Plant Repairs	$14,675
Property Repairs	$5,125
Telephone - Farm	$1,278
Total	$85,578

Table 19 shows the current plant inventory for the beef enterprise and the calculation of depreciation. It should be noted that this depreciation allowance is not the one found in the tax returns of the enterprise. The depreciation allowance calculated here was used as a cost in the calculation of the operating profit and it is therefore related to the economic life rather than the depreciation "life" of the item for taxation purposes.

The allowance calculated in Table 19 essentially allows for the use / fall in value of assets that have a life of more than one production period. It is not a cash cost but 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 to estimate the operating profit of the enterprise.

Table 19 Plant inventory and depreciation allowance

Item	Market Value	Years to Replacement	Replacement Cost	Salvage Value	Depreciation Allowance
4wd Ute	$30,000	5	$70,000	$30,000	$8,000
Tractor	$45,000	30	$65,000	$20,000	$1,500
Farm truck	$75,000	15	$92,000	$30,000	$4,133
Motor Bikes	$10,000	10	$20,000	$0	$2,000
Quad bike	$3,000	10	$12,000	$3,000	$900
Slasher	$1,500	20	$7,000	$1,500	$275
Fuel trailer	$1,750	25	$3,500	$1,000	$100
Welder trailer	$5,000	10	$10,000	$2,000	$800
Molasses Tank Mixer	$7,000	25	$12,000	$5,000	$280
Workshop and saddlery	$25,000	16	$40,000	$0	$2,500
Total	$203,250		$331,500		$20,488

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 minus salvage value) divided by the remaining life in years. The replacement cost is an estimate of how much it would cost to replace the item if it were to be replaced now. The salvage value is estimated on the basis of the item being valued now but with the item in a condition equivalent to what it will be in when it is replaced.

The value of the land and fixed improvements for the example property was taken to be $5,872,500. This made the opening value of the total value of land, plant and improvements for the beef enterprise investment was $6,075,750. The investment analysis identified that the beef property returned about 1.3% on the capital invested over the investment period. No allowance for any potential change in the change in the real value of the land asset was included. A growth in asset value in real terms can impact the expected investment returns. For example, if the underlying land assets grew at 2% per annum in value in real terms, the investment return would almost double from 1.3% to about 2.4% per annum.

5.3 Optimising steer sale age and female culling

This section checks whether the current steer sale age is the optimum and whether the current female culling strategy can be improved.

5.3.1 Optimising steer sale age

Table 20 shows summary data for a range of ages for steer turnoff for the starting herd structure. There is sufficient difference between the turn off ages of 12-24 months, 24-36 months and the current turnoff age of 36-48 months to justify a change if any of the younger sale ages was the current target. The entire older steer sale ages were more profitable than selling the steers as weaners - even though the highest price per kilogram was expected to be received for weaner steers over time.

In general, targeting the sale of slaughter steers off buffel was likely to produce the most profit for the enterprise – as long as market criteria were consistently met.

Table 20 Analysis of steer sale age

Parameter	Starting herd (36-48 months)	Weaner steers (6 month)	Yearling steers (12-24 months)	Feed on steers (24-36 months)
Total adult equivalents	1500	1500	1500	1500
Total cattle carried	1370	1185	1367	1480
Weaner heifers retained	133	211	189	168
Total breeders mated	558	886	792	705
Total breeders mated & kept	465	738	660	587
Total calves weaned	433	687	615	547
Weaners/total cows mated	77.60%	77.60%	77.60%	77.60%
Weaners/cows mated and kept	93.19%	93.19%	93.19%	93.19%
Overall breeder deaths	4.53%	4.53%	4.53%	4.53%
Female sales/total sales %	49.48%	46.42%	47.44%	48.46%
Total cows and heifers sold	188	298	266	237
Maximum cow culling age	13	13	13	13
Heifer joining age	2	2	2	2
Weaner heifer sale & spay	38.48%	38.48%	38.48%	38.48%
One year old heifer sales %	0.00%	0.00%	0.00%	0.00%
Two year old heifer sales %	20.00%	20.00%	20.00%	20.00%
Total steers & bullocks sold	191	344	295	252
Max bullock turnoff age	3	0	1	2
Average female price	$541.43	$541.43	$541.43	$541.43
Average steer/bullock price	$1,228.87	$327.65	$612.21	$814.69
Capital value of herd	$876,749	$819,662	$833,560	$903,216
Imputed interest on herd value	$43,837	$40,983	$41,678	$45,161
Net cattle sales	$336,830	$273,844	$324,767	$333,875
Direct costs excluding bulls	$27,577	$37,082	$34,444	$32,302
Bull replacement	$16,108	$25,580	$22,871	$20,369
Gross margin for herd	$293,145	$211,183	$267,452	$281,204
GM after imputed interest	$249,308	$170,200	$225,774	$236,043

The final age of turnoff selected may be related to the managers' assessment of drought risk. Although, the treatment costs allocated to the herd already include a minor allowance for drought feeding that varies, in total, with the number of breeders run in the herd, it can be seen that the number of breeders retained in each herd structure falls significantly as the age of turn off increases. A yearling steer producer may have about 50% more calving and lactating females during an extended dry season or drought. This increases the mortality risk of the overall herd in drought and may be sufficient for an older age of turnoff to be selected.

5.3.2 Optimising cow and heifer culling and sale age

The female herd structure indicates 83 (38%) of the weaner heifers were culled at weaning, only non-pregnant cows being culled from ages 3-4 to 12-13 years old with all remaining breeding cows culled at 13 years. It is relatively easy to test whether this combination of female culling ages is efficient by optimising the age of culling in the Breedcowplus herd model.

Running the Optimise Female Sales macro produces an interesting result for the base herd. (Table 21) Surplus heifers are now all culled in the 2-3 age group prior to mating (34.48% of the opening number) with no weaner heifers sold. The optimal final cull age for mature cows was still identified as 13 years.

Table 21 Female herd structure after female sales optimisation

Weaner heifers to be retained	201				
Age at first joining (max 3 years)	2				
Cow culling age (integer, max 13)	13				
Required herd size (AE)	1500				
Surplus weaner heifers sold or spayed	0	Weaner %	spayed =	0.00%	
Cow age start year	1	2	3	4	5
Cow age end year	2	3	4	5	6
Cows/heifers available start year	195	189	89	66	55
Sales unmated, % start year cows	0.00%	38.48%	0.00%	0.00%	0.00%
Cows spayed or surplus pre-mating, % of start year	0.00%	0.00%	0.00%	0.00%	0.00%
Sales after mating, % of number mated	0.00%	20.00%	22.00%	13.00%	13.00%
Unspayed cows sold	0	96	19	9	7

Perusal of the Cash Cow project data for the Central Forest country type revealed reproductive performance did not fall greatly with increasing cow age while mortality rates slightly reduced with increasing cow age. (See Table 14 previously) Sale weights and values were also averaged for cull females 3-4 years and older in the model due to a lack of data that identified differences between age classes.

These factors together with the prices paid for the various classes of female beef produced drive the result. Additional data that revealed more about the performance of cows as they aged would be required to change the answer. All breeders older than eight years of age were grouped together as "aged cows" in the Cash Cow data so some averaging of the data for aged and older cows may have occurred. It is possible that aged cows in the Cash Cow Central Forest data represent a cohort of breeders that have been retained in the breeding due to continuing high levels of performance and resilience. Table 22 indicates the GM/AE after interest for the initial cow culling strategy, the optimised cow culling strategy and culling cows at 8 to 9 years.

Table 22 Summary table for Optimise Female Sales comparison

Parameter	Starting herd	Optimised	9 year cull cows
Total adult equivalents	1500	1500	1500
Total cattle carried	1370	1428	1426
Weaner heifers retained	133	201	201
Total breeders mated	558	519	525
Total breeders mated & kept	465	432	433
Total calves weaned	433	403	402
Weaners/total cows mated	77.60%	77.60%	76.52%
Weaners/cows mated and kept	93.19%	93.19%	92.88%
Overall breeder deaths	4.53%	4.53%	4.36%
Female sales/total sales %	49.48%	48.81%	48.91%
Total cows and heifers sold	188	170	170

Maximum cow culling age	13	13	9
Heifer joining age	2	2	2
Weaner heifer sale & spay	38.48%	0.00%	0.00%
One year old heifer sales %	0.00%	0.00%	0.00%
Two year old heifer sales %	20.00%	58.48%	47.75%
Total steers & bullocks sold	191	178	178
Max bullock turnoff age	3	3	3
Average female price	$541.43	$775.66	$768.94
Average steer/bullock price	$1,228.87	$1,228.87	$1,228.87
Capital value of herd	$876,749	$876,038	$877,200
Imputed interest on herd val.	$43,837	$43,802	$43,860
Net cattle sales	$336,830	$350,768	$349,390
Direct costs excluding bulls	$27,577	$27,746	$27,708
Bull replacement	$16,108	$14,990	$15,169
Gross margin for herd	$293,145	$308,033	$306,514
GM after imputed interest	$249,308	$264,231	$262,654

Table 22 indicates the annual profit of the enterprise increased by about $15,000 per annum with the change from weaner heifer sales to older heifer sales so it is probably worth considering how this change in cow culling strategy can be implemented.

It is also apparent that the optimised herd mates fewer cows and produces fewer weaners than the herd that sells weaner heifers but is more profitable. One of the main drivers of the value of the change appears to be the shift in the average net price for females from $541 per head to $775 per head.

To test how different the herd gross margin would be at a younger cull age for cows, an arbitrary maximum cull age of nine years was implemented in the optimised breeder model. The GM after interest reduced from $264,231 for the 13 year age of cull to $262,654 for the 9-10 year age of cull. (Table 22) This is obviously not sufficient, without further data, to convince any manager currently culling at 9 10, 11, 12 or 13 years of age in the Fitzroy catchment to change their strategy.

5.3.3 The impact of price on the relative performance of steer sale ages

The price basis for each class of livestock was derived from Roma store sale data and Dinmore abattoir prices achieved between July 2008 and November 2015. These prices were taken to be representative of long term averages but there has been a considerable and sustained increase in the price paid for beef since the middle of 2014. As long as the price basis (relationship) between the different classes of steers does not change, the rising prices will make all options more profitable and the ranking of the options will remain. However, there is some evidence that the demand for younger classes of steers (weaner and lighter steers) have improved in price more than the finished classes of steers over recent times.

Figure 7 and Figure 8 show the difference in saleyard price between major classes of steers recorded by Meat and Livestock Australia since 2012 (MLA 2017)

Figure 7 – The difference in Queensland saleyard price ($/kg liveweight) of medium (400-500 kg) relative to heavy weight (500-600 kg) steers between 05/07/2012 and 22/06/2017

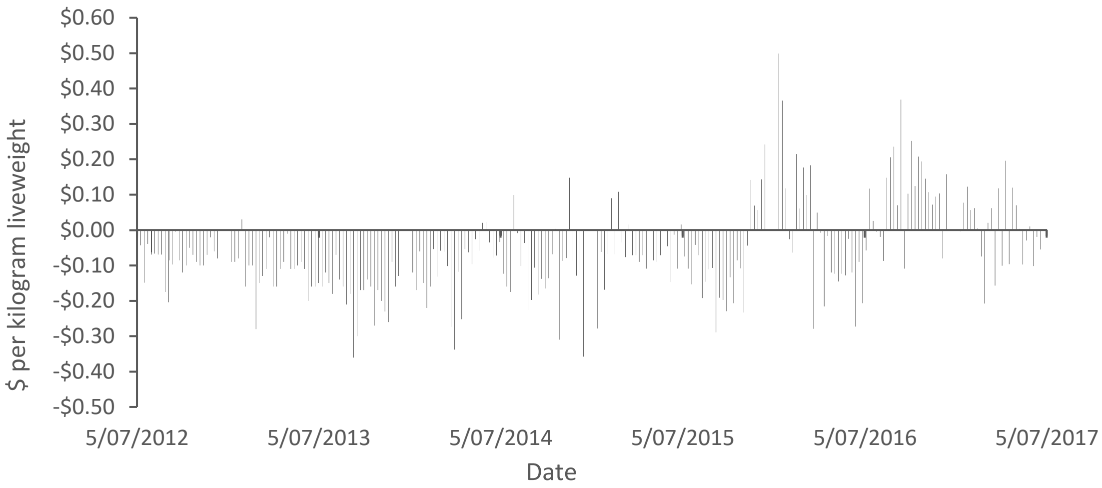
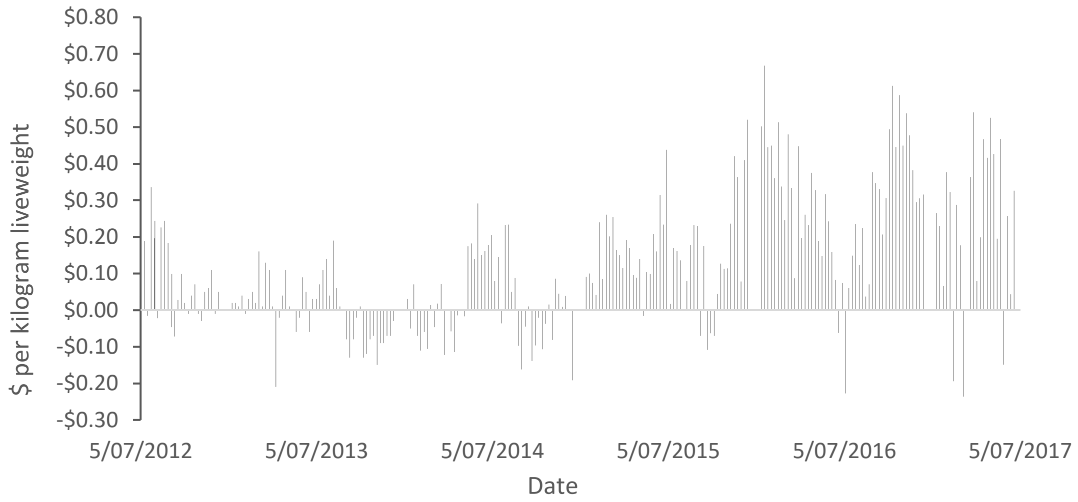


Figure 8 – The difference in Queensland saleyard price ($/kg liveweight) of trade (330-400 kg) relative to heavy weight (500-600 kg) steers between 05/07/2012 and 22/06/2017



There has been a noticeable shift in the price basis between younger/lighter steers and older/heavier steers with not so much change between medium steers and heavy steers. The main drivers of this appear to be the combination of the overall shortness of supply of cattle and steers, property managers restocking with younger steers after drought and the impact of the live export market on young steer prices in northern Australia.

Much of this change in the price basis for steers has not been captured in the analysis and could have substantial implications for the outcomes if continued into the future. Based on current steer prices there could be a case for targeting the production of lightweight steers.

Beef enterprise managers thinking of targeting heavier steers at current prices would need to incorporate the steer price basis, relevant to their options, into their calculations at the time the decision is being made.

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

Some beef producers who currently target the production of weaner steers may be thinking about targeting steer sales at an older age. There can be important impacts on cash flow, profit and investment returns when a change to an older age of turnoff was implemented. The conversion of the breeding herd from targeting weaner steers to targeting 3-4 year old bullocks was modelled to explore the impact on cash flow and profit.

Table 23 shows the results of the thirty-year analysis that looks at the value of converting from weaner steer production to 3-4 year old steer production. It can be seen that a significant deficit occurs (-$105,693) as the breeder herd was reduced and the steer herd retained to the older sale age. The property manager considering the changed age of sale for steers would need to consider the impact of this deficit on the cash flow of the property. Overall, making the change added about $41,000 to the annual profit of the enterprise and it was year four before the cash flow issues were reduced.

Table 23 Investment analysis for converting from weaner steer production to 3 to 4 year old steer production

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$822,777
Annualised return (profit/year for analysis period)	$53,523
Period of analysis (years)	30
Peak deficit (with interest)	-$105,693
Years to peak deficit	4
Payback period (years)	4
IRR of "Change" advantage	n/c

Table 23 shows the difference between the two scenarios or the marginal return. The extra costs incurred to produce steers older than weaners were less than the extra benefits and the marginal return is positive (enterprise profit is improved).

5.3.5 The importance of price in determining the most profitable production system.

The differences in price between classes of beef, the proportion of female and steer beef produced at each of age of turnoff and the efficiency of beef production drives the relative levels of profit produced by different ages of steer turnoff. Although steer weaners usually sell for the highest price per kilogram live, the change in herd structure required to produce the weaner steers increases female beef as a proportion of total beef output and can make that option the least profitable.

The difference in price and growth rate between each steer age class also contributes. Table 24 shows the difference in average price between steers in the 401-550 kilogram category at Roma and the Dinmore grass fed Jap Ox price (liveweight basis) for the last eight financial years. The 2013-14 financial year relationships were greatly impacted by drought and other factors with a very large destocking across north Queensland causing a significant oversupply of store steers.

Table 24 Price margin for steers 401-550 kg and grass fed Jap Ox at Dinmore (cents per kilogram live)

Financial year	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Average
Price difference	17	6	14	14	1	-9	5	22	9

The current price difference for feed on and slaughter steers was set at 2 cents per kilogram liveweight equivalent in the herd model. This was based on the average price data for July 2008 to November 2015. If this price margin was increased to 20 cents per kg live in favour of the feed on steer age of turnoff (recent history), the GM/AE after interest increases to about 4% better than the Jap Ox (Slaughter steer) GM/AE.

This was not as significant as the 19% fall in GM/AE that occurred due to shifting from older steer production to weaner steers even though the weaner steer price was 9.6% higher than the equivalent liveweight Ox price. The weaner production system also produces a lower output due to the requirement to hold a larger number of unproductive replacement heifers. Using a relatively low (in historical terms) opportunity cost of herd capital of 5% per annum also reduced the impact on GM/AE (after interest) of the change in herd capital with each change in herd structure.

There are real limits to increasing the age of turnoff in steers past weights and grades acceptable to the market. Adding sale weights for older steers and resetting the Breedcowplus model to produce steers at 4 to 5 years old (and receiving a price penalty for age and weight) produced a GM $21,000 per annum lower than that for the 3 to 4 years turnoff age.

Consideration of price differences for all of the various classes of livestock in the herd is critically important when assessing the profitability of change. Herd profit can be improved significantly by increasing the proportion of high value steer beef in the herd. This is not done by focusing on steers with the highest value per kilogram (usually weaner steers) or highest value per head, but by focussing on the most efficient balance between steer and female beef in the herd and the most efficient beef production system. Consideration should also be given to the flexibility of turnoff and drought resilience that may be provided as the targeted final age for steer turnoff increases.

5.4 *Strategies targeting steer performance*

The following section analyses a selection of management strategies commonly identified as capable of improving the profitability of a beef property in the Fitzroy catchment. The change parameters were applied to the herd optimised for female culling using the Breedcow and Dynama programs.

5.4.1 Improving growth path performance with forage oats

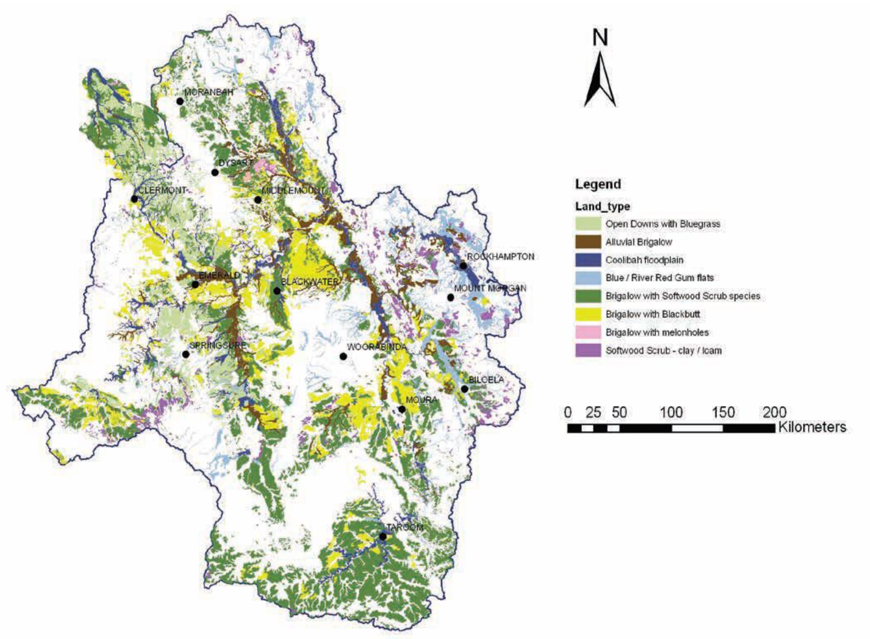
Soil fertility, soil water holding capacity and seasonal rainfall are the main characteristics determining the suitability of a paddock for forage cropping in the Fitzroy catchment.

Bowen et al (2015a) identified the following advantages for forage crops over native and sown grass-only pastures. They can:

- provide higher quality feed (i.e. more digestible and higher protein)
- allow higher stocking rates due to higher forage yields
- provide grazing, or fill a feed gap, when the quality of grass-only pastures is low, for example in autumn, winter or spring

Figure 9 shows the major land types suitable for high quality pasture and forage crop production in the Fitzroy River catchment.

Figure 9 Land types with suitability for high quality pasture and forage crop production in the Fitzroy River catchment (Bowen et al 2010)



Forage oats (*Avena sativa*) is the most widely used winter forage due to its high forage production and quality of feed. It is productive at the time of the year when native and sown grass pastures are dormant, enabling good weight gains when cattle would otherwise be maintaining or losing weight (Bowen et al 2015a).

Oats can provide feed from winter through to early spring, with spring heat and low soil moisture dictating the length of the season. In good seasons, two to three grazing's can be achieved however low winter rainfall causes missed planting in some years and low production in others.

This scenario compared the “without change” system that does not grow forage oats with a “with change” system that invests in machinery to grow forage oats. It was assumed that no development costs were required as a suitable oats paddock capable of being planted with minimal extra expense already exists in a “fenced and watered” state.

Table 25 lists the plant and equipment required to grow about 100 to 200 hectares of oats per annum using a minimum tillage farming system. The purchase cost of the equipment was $152,000 second hand. The equipment incurred a depreciation allowance of $8,575 per annum.

Table 25 Machinery investment required to grow oats

Item	Cost (second hand)	Replacement cost	Time to replacement	Salvage value	Depreciation allowance
Tractor	$65,000	$65,000	10	$25,000	$4,000
Spray rig	$17,000	$20,000	10	$5,000	$1,500
Planter	$45,000	$45,000	20	$5,000	$2,000
Tyne cultivator	$10,000	$10,000	20	$1,000	$450
Chisel plough	$15,000	$15,000	20	$2,500	$625
Total	$152,000				$8,575

Table 26 lists the expected variable costs of growing oats. Machinery operations incorporate labour costs at $25 per hour. The machinery operating costs of fuel, oil, repairs and maintenance were initially calculated on an hourly basis then converted to a cost per hectare based on the expected rate of use.

Table 26 Variable costs associated with oats growing

Parameter	Rate of application	cost / unit	applications	% of forage area treated	per hectare
Pre planting costs					
Chisel plough	1.00	$34.41	1	100%	$34.41
Tyne cultivator	1.00	$17.74	1	100%	$17.74
Linkage spray rig	1.00	$3.66	2	100%	$7.33
Amicide 625	0.75	$6.83	2	100%	$10.25
Glyphosate 450 CT	1.50	$4.64	2	100%	$13.91
Planting Costs					
No till seeder	1.00	$13.66	1	100%	$13.66
Oats seed	40.00	$1.80	1	100%	$72.00
No till seeder	1.00	$13.66	1	100%	$13.66
Urea	43.47	$0.50	1	100%	$21.74
Post Planting Costs					
Linkage spray rig	1.00	$3.66	1	100%	$3.66
MCPA LVE	1.00	$10.75	1	100%	$10.75
Total forage annual costs					$219.09

Steers grazing the oats were treated with 5 in 1 vaccine at a cost of $0.50 per head.

Bowen et al (2015b) described the expected production parameters for commercially grown forage oats in the Fitzroy River catchment. They recorded the performance of forage oats at eight sites over three winter seasons. The oats was sown and managed by beef producers as part of their normal commercial operations with data collected for plant and animal production by project staff as the forage progressed.

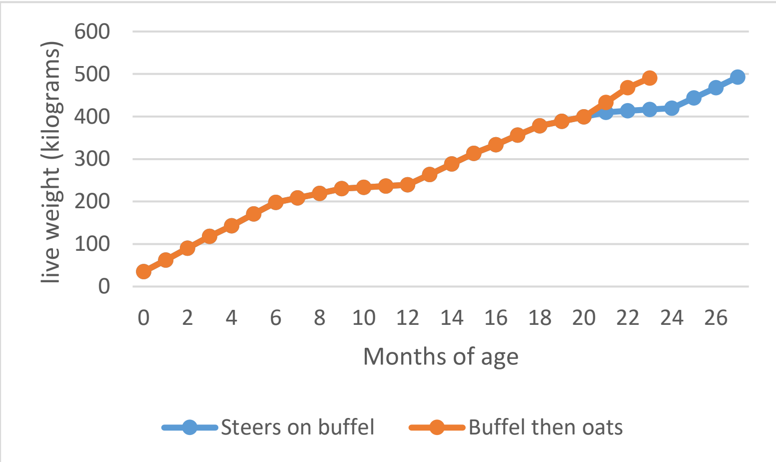
The oats was assumed to provide grazing for 83 days from mid-July, providing an average diet DMD of 65% and resulting in an average steer growth rate over this period of 1.1 kg/day (Bowen *et al.* 2015*a*, 2015*b*). The APSIM modelling framework (The Agricultural Production Systems Simulator; McCown *et al.* 1996; Keating *et al.* 2003) was used to simulate median annual forage biomass production for the location using 117 years of climate data and assuming 100 kg N/ha as a base N level (Cox 2009): 5432 kg DM/ha. It was assumed that 30% of the annual oats biomass was utilised (from data collected from commercial properties; Bowen *et al.* 2015*b*). The carrying capacity of oats forage (2.73 AE/ha) was calculated by dividing the utilisable biomass component by the annual forage DM intake of an AE. An AE was defined here in terms of the forage dry matter intake at the specified diet DMD, of a standard animal as 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 intake for the specified forage DMD.

5.4.1.1 Oats for feed on steers

This section looks at turning off feed on steers at a slightly younger age using oats. The comparison is with a herd that targets feed on steers off buffel.

Figure 10 shows the impact of oats on the growth path of feed on steers. The forage oats allowed steers to reach the feed on weight five months earlier, on average, than the herd model that sold feed on steers off buffel grass.

Figure 10 Growth path that incorporates forage oats to feed on steers



The herd model optimised to target feed on steers off buffel turned off 230 steers in the 2-3 year age group but this number required modification as the area planted to oats reduces the area available for the breeding herd and steers - up to the point the steers go onto the oats. The age steers enter the oats paddock (leave the herd) is also younger than the feed on sale age.

The breeding herd produced 261 steers when configured to focus on selling steers off oats between 12 and 24 months of age. This number did not allow for the area of grazing land lost to oats production. The herd size needs to be adjusted for the area of buffel grass lost to the oats paddock.

The area planted to oats depends upon a number of factors:

- the number of steers to be finished,
- the amount of feed of a certain quality they require to reach sale weights,
- the potential level of utilisation of the forage by the steers (they cannot eat it all), and
- the amount of dry matter required for ground cover at the end of the grazing period

QuickIntake (McLennan and Poppi 2016) calculates steers with an average weight of 445 kilograms gaining 1.1 kilograms per day on oats with a dry matter digestibility of 65% will require 12.4

kilograms of dry matter per day to maintain the weight gain. (The steers go onto the oats at about 399 kilograms liveweight and leave the paddock at about 491 kilograms liveweight) A total paddock size of 190 hectares (forage area 166 hectares) was required for the 261 steers. The average stocking rate on the oats was 1 steer per 0.64 hectares of forage.

The machinery was purchased and oats produced in the first year of the investment period with adjustments to herd numbers made. Three age groups of steers were sold in the first year – the 3 to 4 year old bullocks were sold as usual in February, the 2-3 year old steers were sold in March and then the first group of 1 to 2 year old steers were sold off oats at the end of October in the same year. Only the steers produced off oats were sold in following years. The number of cows mated was increased over time from 519 to 700 to adjust for the younger age of turnoff associated with incorporating oats in the growth path of the steers.

The frequency of suitable planting conditions for oats must be considered as production from forage oats is more variable than production from a grass pasture that could be utilised in this paddock. The percentage of years with conditions suitable for sowing oats are shown in Table 27 for three sites across the Fitzroy River catchment. These figures were derived from the plant production model, APSIM (Agricultural Production Systems Simulator (McCown et al 1996)) and were based on regional soil characteristics, and 108 years of historical climate data. (Bowen et al 2015a)

Table 27 Percentage of years with suitable conditions for sowing annual forage crops in the Fitzroy River catchment (Bowen et al 2015a)

Region	% of years
Central Queensland Open Downs (Emerald-Capella area)	62
Central Queensland Brigalow (Biloela-Rolleston area)	67
South Queensland Brigalow (Taroom–Wandoan area)	67

Adjustment was made to the expected income from steer sales and forage growing costs to allow for oats only being successful in 67% of years. The adjustments were:

- In those years in which oats was planted, the average steer weights and oats growing costs applied.
- When a planting opportunity didn't occur, the steers were sold in July at their oats paddock entry weight less 5% for weight lost during the selling process.
- In years when crops were not planted the planting costs were set at 44% of the costs incurred when oats was planted. That is, only fallow costs were incurred in a year when no planting opportunity arrived.

Table 28 shows the calculation of the expected sale value received for steers when the oats enterprise investment was made and the risk of failure to plant is taken into account.

Table 28 Calculation of expected steer weight, price and selling costs for oats enterprise

Parameter	frequency	Steer paddock weight	Steer sale weight	steer price	gross /head	Selling costs	Net price
Not planted	33	399	379	$1.90	$720	$71.60	$649
Planted	67	491	466	$1.90	$886	$78.24	$808
Expected value	100		437	$1.90	$830	$79	$751

Table 29 shows the calculation of the expected value for variable costs for oats. Those years where oats is not planted just incur the fallow costs with all planting costs incurred in years that oats is planted.

Table 29 Calculation of expected value of variable costs for oats enterprise

Parameter	frequency	variable costs per hectare	total expected value
Not planted	33	$83.62	$13,406
Planted	67	$219	$35,040
Expected value	100	$174.32	$27,892

Table 30 indicates the impact on returns of planting oats for feed on steers. Investing to grow oats to sell feed on steers at a younger age appears unlikely to provide an improvement in profitability.

Table 30 Marginal returns for an investment in forage oats for feed on steers

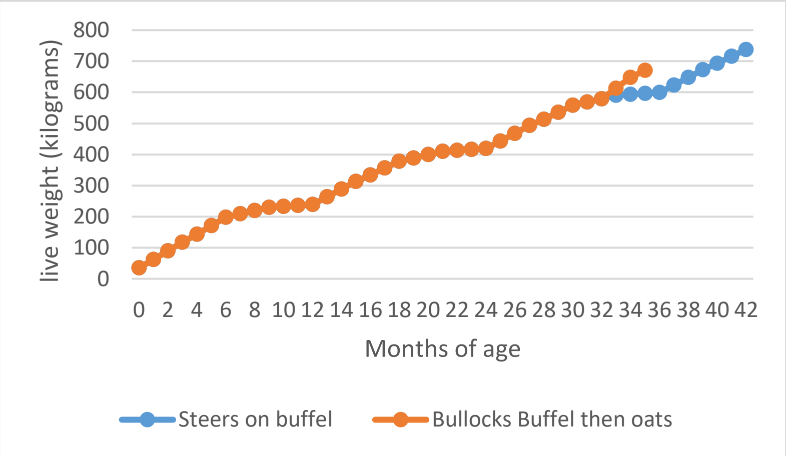
Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$539,079
Annualised return (profit/year for analysis period)	-$35,068
Period of analysis (years)	30
Peak deficit (with interest)	-$1,482,018
Years to peak deficit	30
Payback year	Never
Payback period (years)	Never
IRR of "Change" advantage	n/a

5.4.1.2 Oats for bullocks

In this analysis steers were either finished in May off buffel grass ("without change" model) at a paddock liveweight of 738 kilograms on average or off forage oats in October the year before ("with change" model) at a paddock liveweight of 670 kilograms on average. Steers entered the oats paddock in July at a liveweight of 579 kilograms according to our steer growth model.

Figure 14 shows the impact of oats on weight gain as a divergence to the underlying steer growth model for improved grass pastures. The forage oats finished heavy steers to the abattoirs four months earlier, on average, than the "without change" base herd model.

Figure 11 Growth path that incorporates forage oats to finish bullocks



The "without change" herd model turned off 178 steers in the 3-4 year age group but this number required modification as the area planted to oats reduces the area available for the breeding herd and steers up to the point they go onto the oats. The age steers enter the oats paddock (leaving the herd) is also younger than the current sale age. Table 31 shows the base herd model reconfigured to turn off steers in July at 579 kilograms ready to go onto oats.

Table 31 Herd structure for steers to go onto oats in July (no AE change)

Age at Start of Rating Period	Number Kept Whole Year	Number Sold	AE/Hd Kept	AE/Hd Sold	Total AEs
Extra for cows weaning a calf	na	na	0.35	na	163
Weaners 5 months	466	0	0.26	0.07	120
Heifers 1 yr. but less than 2	226	0	0.69	0.32	156
Heifers 2 yrs. but less than 3	108	111	1.07	0.51	172
Cows 3 yrs. plus	392	85	1.21	0.69	532
Spayed or unmated females all ages	0	0	0.00	0.00	0
Steers 1 yr. but less than 2	224	0	0.72	0.34	162
Steers 2 yrs. but less than 3	0	215	1.12	0.73	157
Bulls all ages	21	3	1.65	0.96	38
Total number	1436	414		Total AE	1500

The breeding herd reconfigured to focus on bullocks off oats weaned about 231 steers and placed 213 steers onto oats. The Breedcowplus model with the steers produced to go onto oats was adjusted to reflect the final sale weight of the steers plus their gross and net sale price. The same assumptions re frequency of oats plantings were applied in this scenario as previously.

Table 32 Investment returns for oats for bullocks with missed oats plantings

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$36,729
Annualised return (profit/year for analysis period)	-$2,389
Period of analysis (years)	30
Peak deficit (with interest)	-$131,523
Years to peak deficit	20
Payback period (years)	n/c
IRR of "Change" advantage	n/c

Table 32 shows the difference between the two scenarios or the marginal return. In this case, the extra costs incurred to produce oats are greater than the extra benefits and the marginal return was negative. The original investment was not repaid within the first thirty years.

Beef producers in the Fitzroy plant forage oats for steers at a number of points in their growth path. These include:

- Oats to weaners to produce yearlings
- Oats to weaners to return to buffel to finish as feed on steers
- Oats to 20 month old-steers to produce feed-on steers
- Oats to 20 month old-steers and then returned to buffel to finish
- Oats to 32 month-old steers to produce bullocks
- Steers onto oats at 8 and again at 20 months to produce light bullocks
- Steers onto oats at 8 and again 20 months and then returned to buffel to finish

The economic impact of these alternative growth paths, and many that also incorporate leucaena, has been identified in a separate analysis (Bowen and Chudleigh 2017).

Investing in a strategy of growing forage oats to sell feed-on steers at a younger age appears likely to substantially reduce profitability of the beef enterprise compared to selling the steers later off buffel, with a -$539,079 NPV over 30 years); (Table 30). Feeding oats to heavy steers to produce bullocks also reduces the profitability of the property.

These results are in agreement with our previous gross margin and whole farm analysis conducted for commercial properties in central Queensland (Bowen et al. 2015b, 2016). They are also in agreement with modelled whole farm scenario analysis for central Queensland conducted by Bowen and Chudleigh (2017) where the incorporation of forage oats into a buffel grass-only growth path for steers always reduced the profitability of both a steer turnover and breeding and finishing enterprise. In contrast to the present study, the analysis of Bowen and Chudleigh (2017) did not account for the proportion of years unlikely to be suitable for planting oats (33% of years) but still found investing in forage oats to reduce the profitability of beef enterprises. Furthermore, as also found by Bowen and Chudleigh (2017), investment in forage oats substantially increased peak deficit levels and financial risk with the investment failing to general sufficient returns to repay the additional borrowings during the 30 years of the investment period.

Our results are in contrast, however, with results of enterprise-scale bio-economic modelling, which indicated potentially large economic benefits from utilising small areas of irrigated annual forages, including oats, as part of beef production systems in central Queensland and northern Australia in general (Bell et al. 2014; Hunt et al. 2014a). The latter studies did not consider the implementation phase for the forage strategies or the marginal returns on the investment at the property level.

5.4.2 Improving growth path performance with legumes

Of the commercially available perennial legumes suited to central Queensland, the tree legume, leucaena (*Leucaena leucocephala* spp. *glabrata*) has been identified as one of the more productive and profitable, increasing beef production by 2.5 times and doubling gross margin per ha, compared to perennial grass pastures. The area planted to leucaena in the prime leucaena-growing areas of Queensland which primarily fall within the Fitzroy NRM region, is currently estimated to be ca. 123,500 ha (Beutel et al. 2018). Assessments of suitable soil and climatic conditions indicate that there is considerable scope to expand plantings within this region as well as 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 it is adapted in Queensland.

Recent research has demonstrated that Desmanthus (*Desmanthus virgatus*) and Caatinga stylo (*Stylosanthes seabrana*) can also be persistent and productive in central Queensland although they have not been widely adopted commercially. The shrubby legume, butterfly pea (*Clitoria ternatea)* has also been shown to be a profitable legume option for central Queensland.

5.4.2.1 Leucaena

Leucaena is a tropical shrub legume that produces high quality forage. It is most productive during the warmer and wetter (summer) months, enabling high animal growth (>1 kg/head/day) for 6–9 months.

Bowen et al (2015a) identified the benefits as:

- It is a highly productive, perennial legume that can persist on a range of soil types for more than 30 years
- It produces highly palatable forage that is high in protein (15–33% crude protein in green leaves and fine stems)
- When grown with a productive grass, high stocking rates (1 AE / 1.5 ha) and total cattle weight gain greater than 250 kg/AE/annum are possible
- No bloat concerns
- It has a deep root system allows the plant to continue growing into dry periods and minimizes deep drainage
- It contributes to soil nitrogen levels, halting soil fertility decline and improves the quality of companion grass.

For this exercise, it was assumed a paddock capable of being planted to leucaena already exists in a "fenced and watered" state. The expected development costs for leucaena are shown in Table 33. The pasture will be developed on the basis of cultivating 5 meter wide strips across the paddock on 10 meter centers. Contract rates for the fallow costs and planting the leucaena are used as the pasture will only be planted once in the 30-year investment period. 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.

Additional expenses is expected to prepare an adequate seed bed in this case as the paddock is being converted from buffel grass to leucaena. Different establishment costs may be incurred if converting from previously cultivated land to leucaena or a different approach is taken. Different approaches to establishing leucaena may also impact the rate at which it can be accessed by steers.

Table 33 Leucaena development costs at contract rates

Parameter	Rate of application	cost / unit	number of applications	% of area treated	per hectare
Pre planting costs					
Chisel plough	1.00	$61.44	2.00	50%	$61.44
Tyne cultivator	1.00	$36.91	2.00	50%	$36.91
Linkage spray rig	1.00	$8.35	2.00	50%	$8.35
Roundup CT	2.00	$4.50	2.00	50%	$9.00
Amicide 625	0.50	$6.83	2.00	50%	$3.42
Planting Costs					
Leucaena planter	1.00	$21.23	1.00	100%	$21.23
Leucaena seed	2.00	$30.00	1.00	100%	$60.00
Leucaena inoculant	1.00	$0.24	1.00	100%	$0.24
Beetle bait	1.00	$7.00	1.00	100%	$7.00
Linkage spray rig	1.00	$8.35	1.00	50%	$4.18
Spinnaker	0.14	$255.00	1.00	50%	$17.85
Roundup CT	1.50	$4.50	1.00	50%	$3.38
Post Planting Costs					
Linkage spray rig	1.00	$8.35	1.00	50%	$4.18
Fusilade	1.50	$69.27	1.00	50%	$51.95
	Total				**$289**

Table 34 indicates the development process applied in the scenario

Table 34 Leucaena development process for buffel grass in the Fitzroy

Scenario	Year 1 Fallow year	Year 2	Year 3	Year 4	Year 5
Brigalow clay	Nine month fallow, plant after Christmas	Year of sowing no grazing	Spell until end of the wet season then graze at 50% of fully established	100% stocking rate; half extra weight gain per head	full stocking rate; full weight gain

Leucaena has a high requirement for soil phosphorus and it was assumed that a soil test revealed a currently adequate state and no additional P will be required to maintain the productivity of the leucaena over period of the investment.

The expected maintenance cost is shown in Table 35 and is expected to be incurred at the end of each decade.

Table 35 Leucaena maintenance costs – expected every decade

Parameter	Rate of application	Cost/unit	No of applications	% of forage area treated	$ per hectare
leucaena maintenance	1.00	$81.51	1	100%	$81.51
Decadal maintenance costs					$81.51

Once fully established, the leucaena pasture will be grazed by steers from weaning until they reach a feed on target weight. They are expected to grow about 40% faster per annum than steers grazing the buffel pasture without leucaena.

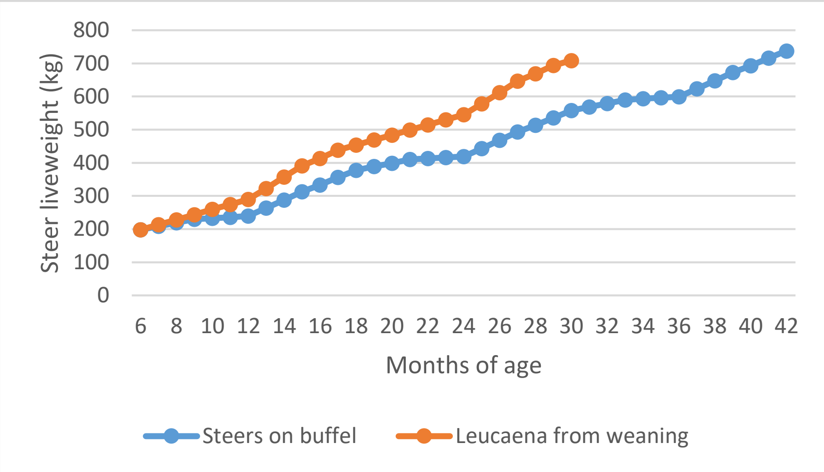
Table 36 indicates the expected difference in average monthly and annual weight gains for steers on buffel and steers on a leucaena buffel grass pasture in the same paddock.

Table 36 Steer growth rates for steers grazing leucaena grass pastures and steers grazing buffel grass

	Buffel steers (kg/d)	Buffel steers (kg /head)	Leucaena steers (kg/d)	Leucaena steers (kg /head)
Total	0.49	180.46	0.70	254.80

Figure 12 indicates the expected growth path for steers on leucaena from weaning and steers on buffel from weaning to about 710 kilograms liveweight.

Figure 12 leucaena and buffel growth paths post weaning to



Steers grazing leucaena from weaning reach a suitable sale weight about twelve months earlier than steers grazing the buffel only pasture.

Table 37 shows the calculation of the area required to run a steer from weaning to bullock sale weight on perennial grass and on an established leucaena grass pasture. The higher dry matter production and the higher digestibility of the leucaena grass pasture underpin the difference in the short term but it is considered likely that increased supplies of N provided by the leucaena will improve grass output over time.

Table 37 grazing area calculation for perennial grass and leucaena pasture

Parameter	Perennial grass	Perennial grass and leucaena
Number of steers	1	1
Days on forage (post weaning)	1095	730
Average weight gain (kg/d)	0.49	0.7
Average age (yrs.)	2.0	1.5
Average weight (kg)	468	453
Average DMD of diet (%)	57	63
DM Consumption per head per day (QuikIntake)	12	11.0
Kgs consumed by livestock (kg dry matter)	13,140	8,030
% of dry matter consumption as grass	100%	50%
%of dry matter consumption as leucaena	0%	50%
Kgs grass consumed by livestock (kg dry matter)	13,140	4,015
Kgs leucaena consumed by livestock (kg dry matter)	0	4,015
Expected utilisation grass (total DM)	30%	30%
Expected utilisation leucaena (edible component)	0%	85%
Expected annual grass production	5100	5,100
Expected annual leucaena production (edible component)		1,800
Expected annual paddock dry matter (kg /ha)	5,100	6,900
Total grass yield for grazing days	15,300	10,200
Total leucaena yield for grazing days	0	3,600
Grass biomass available for consumption	4,590	3,060
Leucaena biomass available for consumption	0	3,060
Hectares required to meet steer demand for 1 year	2.86	1.31
Area (adjusted for number of days > 365) Hectares	8.59*	2.62*

*Note: This is not for an AE but for steers of this age, average weight and weight gain grazing grass or leucaena grass pastures respectively. The steers grazing buffel pastures (to slaughter weight) will need access to about 1,726 hectares from weaning to sale at 42 months of age.

Having all of the yearling steers on leucaena would free up more than 1,200 hectares of land to be grazed by other classes of stock in the breeding herd. If 2.1 hectares is allocated per AE, then the breeder herd component of the overall beef herd can expand in size by about 565 AE once the leucaena is fully established. Proportionally expanding the breeding herd and replacement heifers to graze this spare pasture will allow the breeders to produce more weaner steers, increasing the area of leucaena required but also reducing the spare grass available for breeder herd expansion. An iterative process can be used to approximately identify the relationship between the size of the breeder herd and the numbers of steers grazing the leucaena grass pasture that optimizes the size of each.

A leucaena paddock of about 761 hectares will be needed to provide an appropriate balance between an expanded breeder herd and suitably sized leucaena paddock for the steers. This paddock will be planted at the start of the second year.

Table 38 Breeder herd components without leucaena and with leucaena

Breeder herd components	Without leucaena	With leucaena
Total cows and heifers mated	519	748
Calves weaned	403	581
Weaner steers	201	290

The cost of preparing and planting the leucaena paddock (at contract rates) is $220,000. Table 39 indicates that over the longer term, the profitability of the beef system is significantly improved.

Table 39 Marginal returns for an investment in leucaena

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$840,725
Annualised return (profit/year for analysis period)	$54,690
Period of analysis (years)	30
Peak deficit (with interest)	-$465,728
Years to peak deficit	6
Payback period (years)	12
IRR of "Change" advantage	16.14%

5.4.2.2 Optimizing leucaena returns through the purchase of additional breeders

The conversion to leucaena grazing for all steers from weaning requires the breeder herd to increase in size (from 645 to 748 cows mated) to supply sufficient steers to graze the total area of leucaena planted. Table 40 shows that it takes at least a decade for the new optimum herd size to be reached and about thirteen years for the new level of sales to be achieved if additional heifers are held and the current cow culling strategy altered to build up the breeding herd over time. Given that the leucaena can be fully stocked from year five, it is likely that the leucaena is not being fully utilized for a number of years and that some of the potential benefit of the investment may be foregone.

Table 40 Sales and new calves in transition to leucaena production

Herd Summary	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2033
Total sales	682	329	140	329	360	385	407	430	451	465	479	493	511
Total new calves	400	429	454	474	497	516	531	545	555	563	570	572	576

To look at the impact of the delay in fully stocking the leucaena in investment returns, the leucaena scenario purchased sufficient breeding cows and replacement heifers in the fourth year of the development to stock the leucaena fully with weaner steers from year six. The additional cows and heifers were purchased at the beginning of year four and produced calves in that year. The additional weaner steers went onto the leucaena in year five and sold in year seven. The total landed purchase price for the cows, heifers and bull was about $100,000.

Table 41 Marginal returns for an investment in leucaena and additional females

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$910,120
Annualised return (profit/year for analysis period)	$59,205
Period of analysis (years)	30
Peak deficit (with interest)	-$532,242
Years to peak deficit	6
Payback period (years)	11
IRR of "Change" advantage	16.64%

The payback period is shorter, the peak debt is larger and the annual returns are improved. These results for investment in leucaena-grass pastures are in agreement with those from gross margin analysis conducted for commercial properties, and whole-farm case study analyses, where leucaena-grass systems were identified as the most profitable forage option for beef cattle production in central Queensland (Bowen et al. 2015b; 2016).

The modelling study of Bowen and Chudleigh (2017) considered steer growth paths resulting from access to buffel grass pastures with or without leucaena-grass pastures, or leucaena-grass in combination with forage oats. The most profitable growth path scenario was that where steers grazed leucaena from weaning until achieving feed-on weight. Taking weaner steers through to finishing weights on leucaena was the 2nd most profitable growth path scenario whilst feeding leucaena to steers from the start of their first wet season following weaning to finishing or feed-on weights were the 3rd and 4th most profitable growth paths, respectively. Growth paths that incorporated oats forage in addition to leucaena-grass resulted in lower profitability than similar growth paths that only incorporated leucaena. The growth path providing oats forage twice, in dry season 1 and 2 with leucaena-grass in between, and resulting in the youngest age of turnoff at finished weights, was only marginally more profitable than the buffel only scenario.

The incorporation of forage oats into a buffel-based growth path (without leucaena) always reduced the profitability of the steer turnover enterprise compared to the buffel only scenario of finishing steers from weaning on buffel grass pasture. For all scenarios where the age of turn-off of steers was reduced (compared to the baseline of producing finished steers from buffel grass pastures) and breeder numbers were allowed to naturally increase, the foregone income related to retaining breeders, plus the delay in matching steer weaner numbers to the increased supply of nutrition, significantly reduced the NPV. The purchase of additional breeders generally increased peak deficit but often reduced the time required to pay back the total funds invested.

5.4.2.3 Other perennial legumes

The legumes Desmanthus (*Desmanthus virgatus*) and Caatinga stylo (*Stylosanthes seabrana*) can also be persistent and productive in central Queensland although they have not been widely adopted commercially compared to leucaena. Like leucaena they are most productive during the warmer and wetter (summer) months, enabling high animal growth.

When planted into a highly productive buffel pasture suitable for leucaena development, they are expected to:

- produce highly palatable forage that is high in protein but likely to be slightly less digestible than leucaena
- provide a total annual weight gain about 93% of that produced by leucaena on average,
- have no bloat concerns
- contribute to soil nitrogen levels, halting soil fertility decline and improve the quality of companion grass

For this exercise, it was assumed a paddock capable of being planted to these "other" legumes already exists in a "fenced and watered" state and that the performance of either legume will be similar.

Table 42 Other legume development process for buffel grass in the Fitzroy

Scenario	Year 1 Fallow year	Year 2	Year 3	Year 4	Year 5
Brigalow clay	Nine month fallow, plant after Christmas	Year of sowing Stock at 50% of baseline post July	Stock at 75% of baseline buffel, Spell to allow seeding (3 months spell)	Stock at 80% of baseline buffel, 2 months spell	full stocking rate; full weight gain

Desmanthus and Caatinga stylo have a lower requirement for soil phosphorus than leucaena and it is expected that no additional P will be required to maintain the productivity of the other legumes over time. The expense of chopping as required to maintain productive leucaena is foregone with these legumes as well. The expected development costs for the other legumes are shown in Table 43.

Table 43 other legume 5m cultivated strip development costs at contract rates

Parameter	Rate of application	Cost / unit	number of applications	% of area treated	Cost per hectare
Pre planting costs					
Chisel plough	1	$61.44	2.00	50%	$61.44
Tyne cultivator	1	$36.91	2.00	50%	$36.91
Linkage spray rig	1	$8.35	2.00	50%	$8.35
Roundup CT	2 L/ha	$4.50	2.00	50%	$9.00
Amicide 625	0.5 L/ha	$6.83	2.00	50%	$3.42
Planting Costs					
Drum Seeder	1	$20.89	1	50%	$10.44
Legume seed	2 kg/ha	$28.00	1.00	50%	$28
Rhizobia	1	$2	1.00	50%	$1
Linkage spray rig	1	$8.35	2.00	50%	$8.35
Spinnaker	0.14 kg/ha	$255.00	2.00	50%	$35.70
	Total				**$203**

The development is undertaken on the basis of chemically treating 5 meter wide strips on 10 meter centers to provide a clear strip that the legumes can be planted into. Contract rates are used as the pasture will only be planted once during the 30-year investment period. Additional expenses was expected to prepare an adequate seedbed in that case as the paddock was being converted from buffel grass to other legumes. Lower establishment costs may be incurred if converting from previously cultivated land to other legumes.

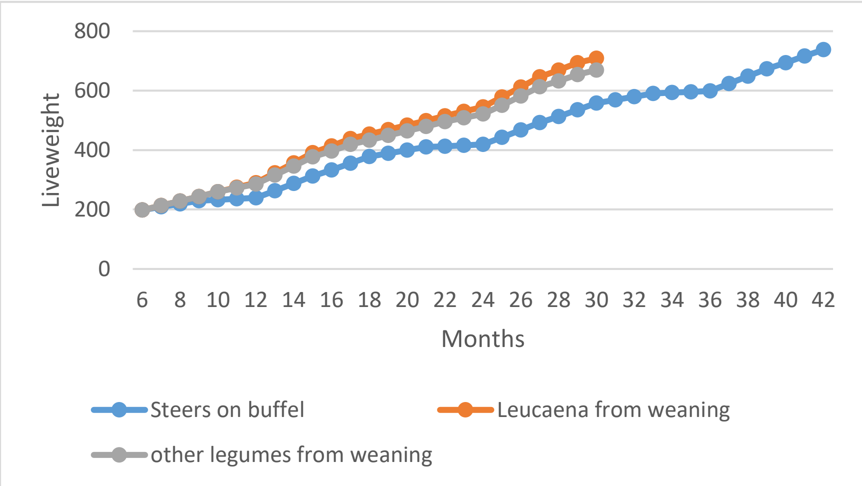
Once fully established the legume pasture will be grazed by the steers from weaning. They are expected to grow about 23% faster per annum than steers grazing the same buffel pasture without legume. Table 44 indicates the expected difference in average monthly and annual weight gains for steers on buffel, steers on a leucaena grass pasture and Desmanthus or Caatinga stylo grass pastures in the same paddock.

Table 44 Steer growth rates for steers grazing buffel grass; leucaena grass pastures and other legume grass pastures

	Buffel (kg/d)	Buffel (kg /head)	Leucaena (kg/d)	Leucaena (kg /head)	Other legume (kg/d)	Other legume (kg /head)
Total	0.49	180.46	0.70	254.80	0.64	235.15

Figure 13 indicates the expected growth path for other legumes.

Figure 13 Other legume growth path



The sale weight of steers coming off other legumes is expected to average 40 kilograms liveweight less than steers that have grazed leucaena from weaning to 30 months of age.

Table 45 shows the calculation of the area required to run a steer to a feed on sale weight on perennial grass and on an established legume grass pasture in the same paddock.

The higher dry matter production and the higher digestibility of the Desmanthus or Caatinga stylo grass pasture underpin the difference in the short term but it is considered likely that increased supplies of N provided by the legume will also improve grass output over time.

Table 45 grazing area calculation for perennial grass and other legume pasture

Parameter	Perennial grass	Perennial grass + other legume
Number of steers	1	1
Days on forage (post weaning)	1095	730
Average weight gain (kg/d)	0.49	0.6467
Average age (yrs.)	2.0	1.5
Average weight (kg)	468	434
Average DMD of diet (%)	57	60
DM Consumption per head per day (QuikIntake)	12	11.4

Kgs consumed by livestock (kg dry matter)	13,140	8,322
% of dry matter consumption as grass	100%	69%
%of dry matter consumption as other legume	0%	31%
Kgs grass consumed by livestock (kg dry matter)	13,140	5,774
Kgs other legume consumed by livestock (kg dry matter)	0	2,548
Expected utilisation grass (total DM)	30%	30%
Expected utilisation other legume (edible component)	0%	45%
Expected annual grass production	5100	5,100
Expected annual other legume production (edible component)		1,500
Expected annual paddock dry matter (kg /ha)	5,100	6,600
Total grass yield for grazing days	15,300	10,200
Total other legume yield for grazing days	0	3,000
Grass biomass available for consumption	4,590	3,060
Other legume biomass available for consumption	0	1,350
Hectares required to meet steer demand for 1 year	2.86	1.89
Area (adjusted for number of days > 365) Hectares	8.59	3.77

As identified previously, the steers grazing buffel pastures to slaughter weight will need access to about 1,726 hectares from weaning to sale at 42 months of age. Having all of the steers on the legume pasture would free up about 970 hectares of land to be grazed by other classes of stock in the breeding herd. If 2.1 hectares is allocated per AE, then the breeder herd component of the overall beef herd can expand in size by about 456 AE once the other legume is fully established.

Proportionally expanding the breeding herd and replacement heifers to graze this spare pasture will allow the breeders to produce more weaner steers, increasing the area of other legume required but also reducing the spare grass available for breeder herd expansion. An iterative process can be used to approximately identify the relationship between the size of the breeder herd and the numbers of steers grazing the legume grass pasture that optimizes the size of each. A legume paddock of 1,008 hectares will be needed to provide an appropriate balance between an expanded breeder herd and suitably sized legume paddock for the steers. This paddock will be planted at the start of the second year.

Table 46 Breeder herd components without the legume development and with the legume development

Breeder herd components	Without other legume	With other legume
Total cows and heifers mated	519	689
Calves weaned	403	535
Weaner steers	201	267

The cost of preparing and planting the other legume paddock (at contract rates) is about $205,000. Table 47 indicates the impact on returns of planting other legumes. The predicted returns rely on some largely untested assumptions concerning the productivity of these types of legumes over time and during the establishment process. Even so, there appears potential for the profitability of the beef system to be improved.

Table 47 Marginal returns for an investment in other legumes

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$458,395
Annualised return (profit/year for analysis period)	$29,819
Period of analysis (years)	30
Peak deficit (with interest)	-$436,067
Years to peak deficit	7
Payback period (years)	14
IRR of "Change" advantage	12.63%

5.4.3 Feedlotting steers

Feedlotting, using a custom feeding arrangement at a large commercial feedlot, is also a potential way to increase the output of beef. In this scenario, steers were sent from the property to a feedlot on the Darling Downs and arrived there at a liveweight of 470 kilograms. (Feed on sale weight less transport weight loss) The custom feeding assumptions were:

- they were fed for 105 days,
- they achieved an average daily liveweight gain of 1.94 kilograms, and
- they consumed an average of 14.8 kilograms of feed a day
- they averaged 377 kilograms dressed weight at slaughter,

Table 48 shows the detailed calculation of weight gain, costs and profit margin for the expected value of custom feeding the steers based on data available on the Beef Central Website. (https://www.beefcentral.com/lotfeeding/)

Table 48 Feedlot costs and returns

Costs of the enterprise					per head	Total
Number of livestock to be fed			230			
What is each animal worth?						
Initial weight			470	kg		
Price (dollars /kg)			$1.89			
Cost of stock into the feedlot					$888	$204,309
Costs of accessing the livestock	head/deck	kms	per km			
Trucking	25	500	$2.00		$40.00	$9,200
Induction					$15.00	$3,450
What will be the final weight?						
Expected average weight gain per day		1.94	kg			
Estimated number of days in the feedlot		105	days			
Total expected gain		203.7	kg			
Final weight		673.7	kg			
How much food will be consumed?						
Average weight during time in the feedlot		571.85	kg			
Average daily feed consumption @	3%	14.811	kg			
Total consumption		1555	kg			
As is feed consumed (90% dry matter)		1728				
Feed Cost ($/tonne)	$310.00					
Total feed cost					$535.68	$123,206
What other feedlot costs are there?						
Interest on steer cost		5.00	%		$12.78	$2,939
Interest on feed cost		5.00	%		$3.85	$886
Losses (% of opening number)		0.25	%			
Total costs					**$1,495.42**	**$343,990**
What will be the output of the enterprise?		No sold	229.43			
Steer selling price	$1.94	$/kg live x	674	kg live	$1,306.98	$299,854
less	selling costs		Livestock levy		$5.00	$1,147
	head/deck	kms	per km			
Extra freight	18	250	$2.20		$30.56	$7,010
Commission on sales	0.00%				$0.00	$0
Net income from sales					**$1,271.42**	**$291,697**
Gross margin					-$224.18	-$52,294

It costs $40 per head to transport the steers to the feedlot ($9,200 per annum), $15 per head for induction into the feedlot ($3,450 per annum), $310 per ton for combined feed and custom feeding charges ($123,206 per annum, $535 per head), and $30.56 per head to move the steers from the feedlot to the abattoirs ($7,010 per annum). The steers were expected to weigh 674 kilograms liveweight at the end of the feeding period.

The average price for 100 day grain fed ox at Dinmore abattoirs between 2008 and the end of 2015 was $3.60 c/kg dressed. The average dressing percentage was 54% indicating a liveweight equivalent price of $1.94 per kilogram.

The feedlot steers final weight was imported into the base herd model to show the transition to feedlot steers in the first year. There is a change to herd structure due to the change in the age of turnoff. Additional steers will be sold in the first year and the breeder herd will increase numbers over time.

The predicted investment returns suggest that producing feed on steers and then putting them through a custom feedlotting system was not a worthwhile ongoing venture for this property.

Table 49 indicates the impact on returns of feedlotting steers.

Table 49 Marginal returns for an investment in feedlotting

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$1,085,730
Annualised return (profit/year for analysis period)	-$70,628
Period of analysis (years)	30
Peak deficit (with interest)	-$2,988,831
Years to peak deficit	never
Payback period (years)	never
IRR of "Change" advantage	n/a

The predicted investment returns suggest that producing feed on steers and then putting them through a custom feedlotting system was not a worthwhile venture for this property.

5.4.4 Hormone growth promotant (HGP)

Hormone growth promotants (HGPs) can increase growth rates of cattle by 10-30% and feed conversion efficiency by 10-15% with the result dependant on the period over which the cattle were treated and the nutrition available (Hunter 2009).

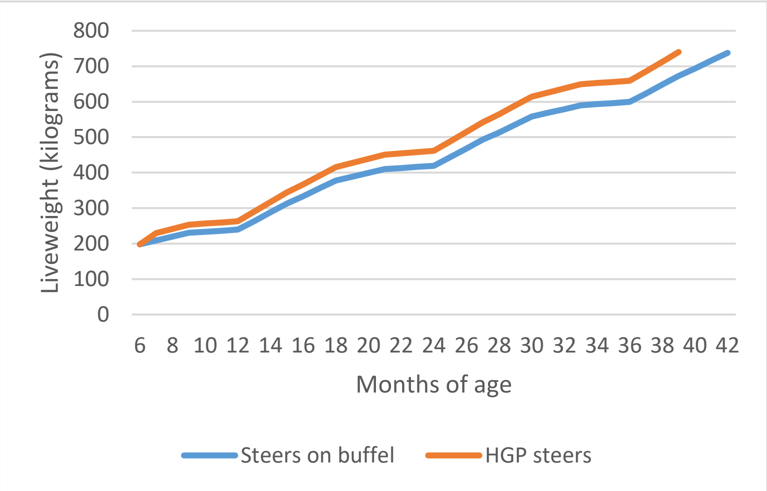
The increased growth rates can have a substantial benefit, enabling the weight-for-age specifications of the target market to be met, particularly when cattle are grazing perennial grass-only pastures. However, cattle treated with HGPs are excluded from the European Union (EU) and the Pasturefed Cattle Assurance System (PCAS) markets.

In addition, HGP treatment can make it more difficult to achieve the MSA grading specifications required to achieve maximum price per kg carcass weight as HGP-treated cattle have a higher ossification score and receive an additional penalty in the MSA grading system. HGPs can also increase carcass leanness by 5-8% and thus may not be beneficial when late-maturing genotypes are used to produce beef for markets requiring substantial fat levels at light carcass weights (Bowen *et al.* 2015*a*).

McLennan (2014) identified a range of improved growth rates for steers treated with Hormone Growth Promotant (HGP) in northern Australian growing conditions with an average of about 10% improvement in the final weight of treated steers. A number of HGP trials reported by Hasker (2000) and held over a wide range of production environments indicate a range of improvements (5% to 15%) depending upon the period the animals were treated and the nutrition available.

The initial scenario applied increased the growth rate of steers post weaning so they achieved a 10% heavier liveweight at the point of sale. This aligns with the results achieved by McLennan (2014) for Brahman cross steers treated long term with HGP's. The cost of achieving this additional growth is three treatments with HGP that have effect over two 400 day and one 200 day periods. Figure 14 shows the expected growth path of the steers treated with HGP.

Figure 14 Growth path of HGP treated steers



Steers sold three months earlier at 740 kilograms liveweight in the paddock and maintained the same price point.

The feed efficiency of the steers is also impacted by the use of HGP's. A review of numerous feedlot experiments in the US concluded that the average increase in LWG was 18%, the average increase in feed intake expressed as kg/d was 6%, and the average increase in feed conversion efficiency was 8%. This and other research identifies an important question of biological and economic significance.

That is, is the higher daily feed intake of implanted cattle associated with their increase feed requirements due to increased liveweight or whether hormone treatment increases feed intake per se. Studies where cattle consumed feedlot or forage diets are consistent in indicating that there is no trend for implanted steers or heifers to have higher feed intakes on g of feed /kg of liveweight basis than their non-implanted contemporaries. Consequently, it is reasonable to conclude that implanted cattle eat more feed per day because they are heavier not because hormone treatment increases the drive for feed consumption.

For single implantations, the hormone formulations which resulted in the largest responses in growth rates are those which resulted in the largest improvements in feed conversion efficiencies. The improvements in feed conversion efficiency with HGP treatment are of commercial significance for feedlots because the feed costs per unit of liveweight gain are decreased. On this basis, implanted cattle would require 8% less food to achieve the same growth rate as non-implanted cattle.

Hence, if we assume cattle grazing tropical pastures have a 10% increase in growth rate as per McLennan (2014), then feed efficiency could be increased by 4.5% (cf. 18% and 8%, respectively, of Hunter 2009). That is, implanted cattle in this environment on pasture with the identified quality consume 4.5% less feed to achieve the expected weight gain than if they were not implanted.

The herd model was adjusted to reflect the greater weight of steers in the herd. The AE ratings were also adjusted to allow for the pasture intake being 4.5% lower as a lower proportion as it increases liveweight. The cost of HGP treatment is $20 (400 day) and $7 (200 day) per head including treatment costs.

The use of HGP's in the steers allocates proportionally less of the total property feed resources to the steers and will allow the number of breeders to increase proportionally if the same overall grazing pressure is to be applied. (Table 50) This slightly increases the number of weaner steers available to be treated.

Table 50 Breeder herd components for the base herd and with steers treated with HGP's

Breeder herd components	Base herd	With HGP
Total cows and heifers mated	519	536
Calves weaned	403	416
Weaner steers	201	208

Table 51 indicates the impact on returns of using HGP's to turn bullocks off three months earlier.

Table 51 Marginal returns for HGP use – same price for sale steers

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$30,529
Annualised return (profit/year for analysis period)	$1,986
Period of analysis (years)	30
Peak deficit (with interest)	-$49,529
Years to peak deficit	8
Payback period (years)	17
IRR of "Change" advantage	9.65%

Table 51 shows a slightly positive impact for treating steers with HGP. The peak deficit was caused by the requirement to adjust breeder numbers upwards by retaining heifers from sale and the delay between spending on HGP's and selling the first lot of heavier steers.

Earlier analyses of the impact of HGP's on selling feed on or younger steers indicated that the value of the investment is finely balanced. (Bowen and Chudleigh 2018b) It is very important to get the target market and the herd structure right when applying HGP's. If the steers are sold earlier at the same sale weight, the associated herd structural changes (proportionally more female beef being sold) could make the economics unattractive. If a lower price was achieved at a heavier sale weight, the economics would also be severely challenged.

5.4.5 EU accreditation

Australian beef producers have the opportunity to supply cattle for the European Union (EU) supply chain, provided they meet the market's requirements around traceability and HGP-free status. The EU offers a reliable, high-value opportunity for Australian beef, despite access to the market traditionally being restricted due to tariffs and quotas. Cattle production in the EU is declining, whilst consumption has remained steady, causing a growing beef supply deficit that has been forecast to approach one million tonnes by 2020.

In January 2010, Australia gained access to a new 20,000-tonne tariff-free grain fed beef quota. In 2009-10, Australian beef exports to the EU increased 9% and in 2010-11 increased a further 52%.

Beef destined for the EU must have been supplied through an EU accredited supply chain, including producers, feedlots and saleyards. The European Union Cattle Accreditation Scheme (EUCAS) requires individual animal trace back capability on all animals slaughtered for the EU market.

Producers wanting to supply the EU market must have their properties accredited under the EUCAS. The Australian Quarantine and Inspection Service (AQIS) administers EUCAS. This is a voluntary scheme and there is no application fee.

EUCAS requires accredited farms to:

- have only eligible cattle on their property at all times; that is cattle that have lifetime traceability and have never been treated with HGPs (with the exception of breeding bulls and a small number of house cows)
- only purchase cattle from other accredited properties or saleyards (with the exception of approved non-EU breeding females and bulls)
- identify all cattle on the property with NLIS devices. For cattle born on the property this is to be done at the time of or before weaning (this requirement is different to state or territory National Livestock Identification Scheme (NLIS) requirements)
- use LPA European Union Vendor Declaration (EUVD) forms and specific Scheme transaction tail tags to identify Scheme cattle that are being moved
- ensure their NLIS database account is kept up to date

The terms of EUCAS accreditation are strict. With the exception of breeding bulls, only cattle that have never have been treated with HGPs in their lifetime are eligible to remain on a EUCAS property. Properties with a history of HGP use will have to remove any HGP treated cattle and demonstrate through records the disposal of HGP treated cattle and any unused HGP doses. Cattle with an unknown HGP status or that do not have lifetime traceability must be removed from the property.

Accredited feedlots and accredited saleyards are allowed to have HGP treated cattle on the property; however, stringent EUCAS approved management plans must be in place to ensure these cattle are segregated from EUCAS cattle at all times. Once accredited, cattle must only be purchased from other accredited properties or through accredited saleyards, and these cattle must be accompanied by EUVDs.

This scenario considers the benefits of producing slaughter and feed on steers and heifers specifically for the EU market. Two options will be identified (1) split the steers at a lighter sale weight and sale date and sell the lead to the abattoirs and the tail through the sale yards (2) sell the steers earlier and lighter at the saleyards.

The first sale option will require the steers to be split into two groups at the feed on sale steer weight of 493 kilograms. The lead will be sent to the abattoirs with the tail sent to the sale yards. Table 52 shows the expected split up of the sale steers based on a cut off weight of 475 kilograms for the slaughter steers. This cut off weight should achieve a minimum carcase weight for the group of 240 kilograms after transport losses are accounted for. Approximately 64% will be sent to slaughter with 36% sent to the sale yards.

Table 52 Splitsal analysis of EU steer sale groups

Average (mean) liveweight of group		493				Cut off weight for first sale age	475
Standard deviation (SD) of weights		50				% of group above cut off weight	64%
						Average weight of heavier group	522
Note:	In a "normal" distribution, 95% of individual weights						
	will range from	395	kg to	591	kg	Average weight of lighter group	442
	Adjust entry for SD until range appears correct.					Expected gain if sold at next age	0
						Weight of lighter group by next age	442

The slaughter steers are expected to average 522 kg in the paddock, lose 5% of that weight in transport to the abattoirs, have a dressing percentage 53% and achieve an average carcase weight of 263 kilograms. The expected price is $3.678 per kilo dressed or $1.95 per kilogram live weight at slaughter.

The steers sent to the saleyards have an average weight in the paddock of 442 kilograms liveweight. They lose 5% of this in transit and achieve $2.02 per kilogram live at the saleyards. This is 15 cents per kilogram more than feed on steers that are not EU accredited. The usual selling costs associated with the sale yards apply.

To achieve the EU premium for heifers they have to be culled 12 months earlier. At this age they also achieve a 15 cents per kilogram premium but the herd has to be restructured to account for the change in grazing pressure brought about by the reduced sale age for cull heifers. On average, about 38% of the yearling heifers will be culled. Cull cows will sell at unchanged weights and prices.

There is a three year lag between the decision to gain EU accreditation and when the improved prices are received. This allows time for all steers potentially treated with HGP at weaning to leave the property. It is expected to cost about $10,000 in time and effort to get the property and herd accredited to EU status.

Table 53 EU steers sale price

Category	Paddock weight	Proportion	Sale weight (kg)	Total Kg	Price
EU slaughter steers	522	64	495.9	31,737	$1.95
Feed on EU steers	442	36	419.9	15,116	$2.02
Average	493.2		468.5	46,854	

Table 54 indicates the calculation of the average selling price and selling costs for the two groups of steers turned off.

Table 54 Calculation of net price for EU steers

Category	Value per head	Proportion	Transport	Commission	Other	Per head
EU slaughter steers	$967.01	$61,888.32	$3,436.80		$320.00	58.7

Feed on EU steers	$848.20	$30,535.13	$910.08	$1,221.41	$612.00	$76.21
Total		$92,423.45				$65.00
Average sale value		$924.23				$859.23
Average sale price		$1.97				

The changeover to EU production requires the herd structure to change to accommodate the younger age of turnoff for steers and heifers. Table 55 indicates the herd structure after the change was implemented.

Table 55 Breeder herd components for the base herd and EU steers

Breeder herd components	Base herd	With EU slaughter and feed on steers
Total cows and heifers mated	519	681
Calves weaned	403	529
Weaner steers	201	264

It appears the change to EU accreditation and a focus on selling steers at a younger age is likely to reduce the profitability of the property. A significantly larger price premium would be critical to overcoming the reduction in income related to retaining sale heifers and cows to build up herd numbers during the changeover period. (Table 55)

Table 56 Marginal returns for EU steers and heifers – 64% of steers sent to slaughter

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$134,464
Annualised return (profit/year for analysis period)	-$8,747
Period of analysis (years)	30
Peak deficit (with interest)	-$373,606
Years to peak deficit	never
Payback period (years)	never
IRR of "Change" advantage	n/c

Option 2 is to gain EU accreditation and sell the steers in two cohorts as feed on steers. Table 57 shows the lead of the steers (28%) of the mob being sold in August when the steers are 21 months old. They are expected to average 471 kilograms. The remaining steers are held for a further 183 days when they are also sold with an average weight of 469 kilograms.

Table 57 Splitsal analysis of younger age of turnoff for EU steers

Average (mean) liveweight of group		410				Cut off weight for first sale age	440
Standard deviation (SD) of weights		50				% of group above cut off weight	28%
						Average weight of heavier group	471
Note:	In a "normal" distribution, 95% of individual weights						
	will range from	312	kg to	508	kg	Average weight of lighter group	386
	Adjust entry for SD until range appears correct.					Expected gain if sold at next age	83
						Weight of lighter group by next age	469

The lead of the feed on steers are sent to the saleyards and have an average weight in the paddock of 471 kilograms liveweight. They lose 5% of this in transit and achieve $2.02 per kilogram live at the saleyards. The tail of the steers have a paddock weight of 469 kg when sold and also lose 5% of their paddock weight in transit. Their sale price is 15 cents per kilogram more than feed on steers that are not EU accredited. The usual selling costs associated with the sale yards apply. The heifer cull age is also reduced by 12 months in this scenario and the herd restructured to account for the younger age of sale for 28% of the steers and the cull heifers.

Table 58 Marginal returns for EU steers and heifers – steers all sold as feed on

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$123,566
Annualised return (profit/year for analysis period)	-$8,038
Period of analysis (years)	30
Peak deficit (with interest)	-$339,795
Years to peak deficit	20
Payback period (years)	n/a
IRR of "Change" advantage	n/a

The herd restructuring required to meet the new, younger sale age for steers and heifers together with the moderate price premium for the younger cattle combine to reduce the profitability of targeting the EU market. This is very noticeable when the property was previously targeting heavy slaughter steers at the abattoirs. Other analyses (Bowen and Chudleigh 2018) based on converting from a feed on steer target to an EU market showed more positive results but relied heavily on the price premium being maintained over the longer term.

5.5 Strategies targeting the breeder component of the herd

5.5.1 Feeding production supplements to improve reproduction efficiency

Improving the reproduction rate has been identified as a key factor when seeking to improve the "northern beef enterprise". (McCosker et al 2009, McLean et al 2014, MLA 2015)

Improvements to reproduction efficiency take time to be realised and are likely to involve additional expense. In this scenario, a 5% improvement in the overall weaning rate was sought and was based on improving the body condition of the breeding females prior to calving.

McGowan et al (2104) identified an impact of Body Condition Score (BCS) at the pregnancy diagnosis muster on reproduction efficiency. Table 59 contains results modelled by the Cash Cow project team (McGowan et al 2014) and indicates that cows from the Central Forest data set with a BCS of 3.5 or above at the pregnancy diagnosis muster had a higher pregnancy rate when compared to cows with a BCS of 3 or lower at the same time. Shifting from a BCS of 3 to a BCS of 3.5 (½ a BCS) produced a 5 percentage point shift in the pregnancy rate. The Cash Cow data for the Central Forest country type is seen as closest to that likely to occur in the Fitzroy Catchment.

Table 59 Percentage P4M predicted by body condition score category at the pregnancy diagnosis muster in the Central Forest data based on marginal means generated from the final multivariable model (McGowan et al 2104)

Body condition score category	Mean percentage P4M* (%)
1.0-2.0	45.6^{A}
2.5	55.4^{B}
3	58.8^{B}
3.5	64.0^{C}
4.0-5.0	64.7^{C}

*Means not sharing a common superscript are significantly different (P<0.05).

The multivariate modelling undertaken in the Cash Cow project also predicted the impact of changes in body condition score. "Cows that gained condition between the pregnancy diagnosis (PD) and weaning (WD) musters were predicted to have a significantly higher percentage P4M than those cows that either maintained or lost condition between the PD and WD musters (8.0 percentage points; P<0.001). This difference in performance is independent of all other major factors identified, including BCS at the PD muster and its interaction with country type."

Fordyce et al (2013) report that liveweight in breeding females varied by 12% to 14% per BCS as cows differed from moderate body condition. For a 460kg cow in BCS 3, one condition score equals approximately 13% of body weight or 60kg.

This scenario fed a molasses based production ration during the dry season to lift the body weight of breeders at mating with the target of producing more weaners per cow mated. The initial assumption tested was that a 5% improvement in weaning rate could be gained by lifting the average cow liveweight by 35 kilograms.

The molasses production ration contained molasses + urea + protein meal + salt + DCP + rumen modifier in a ratio by weight of 100:3:10:1:1:0.05 (for Rumensin 100 Premix). This mix is used to finish cattle on pasture but in this case it was fed to breeding stock to improve their reproductive performance. When offered ad lib, intake of the mix can be as high as 1.5% of body weight; e.g. 400 kg steers may eat 6 kg/day; heavier bullocks may eat up to 10 kg/day and, depending on pasture quality and the amount of supplement consumed, weight gains of up to 0.8 kg/day can be achieved. (McLennan 2014)

The model provided an average of 4 kilograms per head per day of the ration for 75 days towards the end of the dry season to increase the average weight of breeders by 35 kilograms at mating. This was an additional expense as no regular supplementation program was in place in the "without change" management strategy except for irregular feeding in response to drought.

The supplement was mixed on farm and cost $300 per tonne. The property already had sufficient infrastructure and equipment to undertake the feeding exercise but extra labour was required to mix and feed out the supplement. The cost of the extra labour was calculated as one day per week for 11 weeks at $200 per day or $2,200 in total per annum.

Each breeder ate 300 kilograms of the mix over the 75 days giving a cost per day for the mix of $1.20 per head per day or $90 per head for the 75 days. The mix was fed to all females older than 24 months retained for mating at a total cost of about $38,000 for the supplement alone or about $40,000 when the feeding out cost was included.

The conception rate in the fed females was increased by 5 percentage points. In this model, the average conception rate of the 3 to 4 year old females was increased from 78% to 83% and the mature females had their average conception rates increased from 87% to 92%. Table 60 shows the values entered for conception rates up to the 9-10 year female age group. The values were the same after this year group.

Table 60 Calving and death rate assumptions for feeding production supplements to breeders

SECTION A: CALVING AND DEATH RATE ASSUMPTIONS

Cattle age start year	Weaners	1	2	3	4	5	6	7	8	9
Cattle age end year	1	2	3	4	5	6	7	8	9	10
To display weaning % calculations, place cursor on column of interest, or block of columns, and press F12 key (Sections A and E only).										
Expected conception rate for age group (%)	na	0.0%	85.0%	83.0%	92.0%	92.0%	92.0%	92.0%	89.0%	89.0%
Expected calf loss from conception to weaning (%)^	na	0.0%	10.0%	7.0%	6.0%	6.0%	6.0%	6.0%	5.0%	5.0%
Proportion of empties (PTE) sold (%)	na	0%	100%	100%	100%	100%	100%	100%	100%	100%
Proportion of pregnants sold (%)	na	0%	0%	0%	0%	0%	0%	0%	0%	0%
Calves weaned/cows retained*	na	0.0%	90.0%	93.0%	94.0%	94.0%	94.0%	94.0%	95.0%	95.0%

Rates of calf loss, the mature cow cull strategy, mortality rates and weaning weights were not changed in the initial analysis. Average mature cow live weights in the breeding herd were adjusted to allow for the additional bodyweight of the breeding females. The adjustment, 15 kilograms, is half the additional weight gained - on the basis that pasture intake was unlikely to increase in direct proportion to the weight gain with some substitution of supplement intake for pasture intake occurring during the feeding period. Cull cow sale weights were increased by 15 kilograms liveweight due to the supplement feeding program.

The price per kilogram received for the cull cows was not changed. The improvement in reproduction efficiency once the feeding program commences required additional yearling heifers to be culled prior to mating to maintain the same grazing pressure. Table 61 provides a summary of the breeder herd with and without production supplements.

Table 61 Summary table comparing "without change" herd with herd fed to improve reproduction efficiency

Factor	Base	+ molasses
Total adult equivalents	1500	1500
Total cattle carried	1428	1417
Weaner heifers retained	201	200

Total breeders mated	519	484
Total breeders mated & kept	432	429
Total calves weaned	403	400
Weaners/total cows mated	77.60%	82.73%
Weaners/cows mated and kept	93.19%	93.41%
Overall breeder deaths	4.53%	4.58%
Female sales/total sales %	48.81%	48.79%
Total cows and heifers sold	170	169
Maximum cow culling age	13	13
Heifer joining age	2	2
Two year old heifer sales %	58.48%	67.34%
Total steers & bullocks sold	178	177
Max bullock turnoff age	3	3

Providing the molasses based supplement to the retained females increased the weaning rate for the total herd by about 5.13%. The key points to notice are that although the weaning rate from total cows mated increases by 5%, the number of breeders mated falls from 519 to 484 and the herd produces a slightly lower number of weaners. The major change is to the proportion of cull heifers in the female sale mix. For the property to be better off, the heifers have to sell for more than the mature breeders they replaced. The numbers of breeders capable of being run within the AE limit of the property is reduced by the slightly heavier bodyweights of the mature breeders and cull cows.

Including the costs of mixing and feeding out of the supplement and the lag in time between feeding the supplement and gaining the benefit provides a more complete measure of the impact of the strategy. Table 62 indicates the impact of the feeding production supplements to breeders on returns. The feeding costs were incurred from year one with the improved weaning rate gained in year two and thereafter.

Table 62 Analysis of investing to change reproduction efficiency

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$503,826
Annualised return (profit/year for analysis period)	-$32,775
Period of analysis (years)	30
Peak deficit (with interest)	-$1,411,054
Years to peak deficit	never
Payback period (years)	never
IRR of "Change" advantage	n/c

In this case, the extra costs incurred to increase the weaning rate were greater than the extra benefits and the marginal return was negative. The beef enterprise was about $33,000 per annum worse off investing to improve reproduction efficiency through feeding production supplements to breeders on the basis of the relationships modelled.

5.5.2 Using genetics to change reproduction efficiency

The capacity to improve the reproduction performance of beef herds across northern Australia via the means of genetic selection has been a focus of research activities. Burns et al. (2014) investigated the genetic control of traditional and novel measures of male reproduction performance and their genetic correlations with critically important female traits, including age at puberty, post-partum anoestrous and traits associated with female lifetime reproduction performance. They found new male traits that are heritable and genetically associated with scrotal circumference or female reproduction traits, and no antagonisms between these male reproduction traits and other production traits. They concluded that these male traits could be used for indirect selection to improve both male and female reproduction performance in northern Australia beef herds. They also estimated that an Estimate Breeding Value (EBV) for sperm motility in Brahman cattle might lift lifetime weaning percentage by 6% in 10 years.

In a related project, Johnston et al. (2013) found early-in-life female reproduction traits are heritable plus alternative measures (such as male reproduction performance, mating outcome, lactation status of first calf heifers and maiden cows) that can be used for capturing genetic variation. They also identified large differences between sires for the early-in-life reproduction performance of their daughters and, although lifetime reproduction traits were lowly heritable, several traits measured early in life were highly genetically related. They found this to be a key result for the future development of genetic evaluation and performance recording and suggested that by focusing on these more heritable, early-in-life traits it would be possible to make significant genetic progress in lifetime reproductive rates.

Johnston et al. (2013) also investigated whether any genetic antagonisms exist with economically important steer production traits. They found that the generally low genetic correlations between steers traits and cow reproduction traits indicated that selection for improved steer performance (i.e. early growth, carcass and meat quality and feed efficiency) could occur without any major antagonisms with female reproduction.

The expected benefits potentially to arise from the improvements in reproduction efficiency described by Burns et al (2014) are tested here by converting a “without change” female herd to a breeding herd with different genes for reproduction that provide a 6% improvement in overall weaning rates. Four alternative scenarios encompassing two starting herd fertilities, a different way of culling heifers to achieve more weaners and a gradual process of introducing the different genes for fertility were modelled. The comparison in each case was to a herd that targeted the sale of feed on steers off buffel.

The first scenario (Scenario 1) immediately replaced the bull herd to provide a 6% improvement in conception rates over time. Heifer culling and mating strategies were maintained the same as the ‘without change’ herd i.e. about 1/3 of replacement heifers were culled before mating with all non-pregnant replacement heifers culled after their first mating. Breeding females were culled on their pregnancy status and age with all non-pregnant cows being culled. The female reproduction performance together with the expected sale weights and prices of the various classes of females produced an optimum herd structure that last mated cows at 12-13 years of age. Replacement bulls cost the same as the average ($5,000) used in the ‘without change’ herd. The net cost of the changeover of all of the herd bulls at the beginning of the investment period was $55,000. (22 x $5,000 for the new bulls less 22 x $2,500 for the old ones (50% of the existing herd bulls were sold on to industry; 50% went to the abattoirs).

Scenario 2 started with the same starting herd and reproduction performance applied in Scenario 1 but altered the heifer culling strategy to cull additional surplus heifers at weaning instead of at 2-3 years old, thereby changing the herd structure to allow more weaners to be produced over time. In

Scenario 2, bull changeover occurred in Year 1, as for Scenario 1. The initial cull rate of 2-3 year heifers was unchanged but the cull rate of weaner heifers increased as reproduction efficiency improved.

Scenario 3 tested the effect of the starting level of reproduction efficiency of the herd. A herd model was constructed at the level of performance representing the bottom quarter of herds Central Forest surveyed by McGowan et al. (2014). The resulting herd had a starting weaning rate of 65% (cf. 77% as assumed for Scenarios 1 and 2). In this scenario, bull changeover occurred in Year 1 as for Scenarios 1 and 2.

Other assumptions underlying the first three scenarios were that the property manager can convert all of the current breeding bull herd to one with different genes in the first year with the first group of "genetically different" calves born in the second year. This is due to the calendar year being used in the analysis and calves being born around November of the first year from the mating prior to the changeover of the bulls.

The final scenario considered the economic impact of replacing the herd bulls as they came due with genetically different bulls. The different genes for fertility were introduced at a slower rate and without the additional capital costs as incurred in Scenarios 1, 2 and 3. In Scenario 4, 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 was that no additional costs would be incurred in herd management with the heifers produced by the bulls with different genes for fertility grouped with the heifers without the genes for fertility of the same age with all subject to the same selection criteria as they moved through the age cohorts of the breeding herd. 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. It was Year 8 before the first lot of heifers produced by a completely changed over bull herd were mated and produced calves in this scenario. Replacement bulls cost the same as the average price ($5,000) used in the 'without change' herd.

Biological responses to each of the production scenarios were assigned with reference to Burns et al. (2014); as well as the expert opinion of scientists and beef extension officers with extensive knowledge of the northern Australian cattle industry. There was little relevant data available to estimate the effect on breeder liveweight, mortality and weaner liveweight, of selecting for genes associated with fertility in northern Australia, so these factors were maintained at the same level in the alternative models.

Another key assumption was that the potential impacts of the genetic selection program was not limited by nutritional or other production constraints expected to be associated with land types and climate typical of the region. Each genetic change scenario was modelled to include the impacts of implementing the change. In scenarios where all herd bulls were changed in Year 1, the reproduction efficiency did not begin to change until the heifers produced by the initial and subsequent mating has entered the herd. Additionally, extra stock produced by the genetic change did not add to the returns of the property until either they were sold as cull females or sale steers. Where bulls with different genes for fertility were introduced to the herd as the existing bull herd became due for replacement (the 'gradual replacement' scenario), the change in reproduction efficiency was apportioned according to the proportion of females with different genes in each females age class mated each year.

The herd model was reset to the required grazing pressure each year in which the conception rate of an age cohort of females changed. This required a slightly different number of heifers to be retained each year to maintain the herd structure necessary to optimise economic returns. That is, all herds (except where additional heifers were culled as weaners) maintained the production targets (maximum age of culling cows, heifer culling age plus steer and cull heifer sale age) that were identified as the economic optimum for the base herd. Cull cows, cull bulls, steers and heifers were sold at the same age, weight and price ($/kg liveweight) regardless of the strategy and no other production parameters were changed.

5.5.2.1 Replace the bull herd in the first year (Scenario 1)

Table 63 indicates the change in weaning rate and other indicators of herd performance as the genes flowed through the breeding herd. The key points to recognise about the values in Table 63 are:

- The optimal culling strategy was maintained at each step to maintain the profitability of the herd. This caused increasing numbers of two year old heifers to be culled prior to mating to maintain the herd structure and grazing pressure.
- The reduced number of cows mated over time to achieve the same number of weaners reflected the impact of the strategy on the reproduction efficiency of the herd.
- Therefore, as the number of weaners produced did not really change, the total number sold from the property did not change but the average value of the females sold increased over time. This reflected the increased proportion of younger, more valuable females in the sale mix as the change was implemented.
- It took 13 years for the predicted increase in the percentage of weaners produced from cows mated to reach the target.

Table 63 Modelled steps in genetic change of weaning rate and herd structure Scenario 1

Parameter	Base herd	Year 4	Year 5	Year 7	Year 9	Year 10	Year 11	Year 12	Year 13
Total adult equivalents	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,537	1,537	1,538	1,538	1,539	1,539	1,539	1,539	1,540
Weaner heifers retained	249	249	249	250	250	250	250	250	250
Total breeders mated	642	633	625	615	608	605	603	601	599
Total breeders mated & kept	535	535	535	535	535	535	535	535	535
Total calves weaned	498	499	499	500	500	500	500	500	500
Weaners/total cows mated (%)	77.60	78.83	79.86	81.26	82.24	82.64	82.98	83.27	83.53
Weaners/cows mated and kept (%)	93.19	93.19	93.24	93.32	93.38	93.41	93.43	93.44	93.45
Overall breeder deaths (%)	4.53	4.53	4.52	4.52	4.54	4.56	4.57	4.58	4.59
Female sales/total sales (%)	47.79	47.79	47.80	47.80	47.79	47.78	47.77	47.77	47.77
Total cows and heifers sold	210	210	211	211	211	211	211	211	211
Maximum cow culling age	13	13	13	13	13	13	13	13	13
Heifer joining age	2	2	2	2	2	2	2	2	2
Two year old heifer sales (%)	58.48	56.77	60.06	64.12	66.56	67.39	67.98	68.40	68.65
Total steers & bullocks sold	230	230	230	230	230	230	230	231	231
Maximum bullock turnoff age	2	2	2	2	2	2	2	2	2
Average female price	$751	$751	$751	$752	$753	$753	$753	$753	$753
Average steer/bullock price	$813	$813	$813	$813	$813	$813	$813	$813	$813

Table 63 indicates that it is likely to take at least 13 years for the weaning rate to improve by about 6% if the entire bull herd was replaced in the first year. The cow culling strategy of the base herd was maintained to allow identification of the net benefits of the change in conception rates.

Table 64 indicates the marginal returns arising from incurring the bull changeover costs ($55,000) at the start of the investment period and continuing the analysis for three decades.

Table 64 Marginal returns for an investment to improve fertility through better genes (Year 1 change, same cost; Scenario 1)

Factor	Value

Period of the analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$50,196
Annualised NPV	-$3,265
Peak deficit (with interest)	-$126,309
Years to peak deficit	n/a
Payback period (years)	never
IRR of "Change" advantage	-11.65%

The beef property was worse off with the investment to change the average conception rate by 6% when changeover costs were incurred. The period of time to the peak deficit and the lack of a payback year in the first 30 years suggests that investment returns would not significantly improve with further extension of the analysis. It appears that if bulls capable of providing the level of change applied in the scenario were available and a changeover cost was incurred, their introduction would reduce economic performance.

5.5.2.2 What if additional heifers were culled as weaners to provide more weaners? (Scenario 2)

One of the outcomes that has caused concern with industry commentators was that the Fitzroy herd improved its reproduction efficiency but only produced about the same number of weaners when the optimum heifer culling strategy was maintained. Although the number of weaners produced by a herd (or the weaning rate) provides no indication of economic efficiency, the herd model was altered to cull additional surplus heifers at weaning, thereby changing the herd structure to allow more weaners to be produced over time. Table 65 shows the steps required to implement the strategy and the time taken for the benefits taken to flow through the herd.

Table 65 Modelled steps in genetic change of weaning rate and herd structure with weaner heifers culled (Cull heifers for more weaners; Scenario 2)

Parameter	Base herd	Year 4	Year 6	Year 8	Year 10	Year 11	Year 12	Year 13
Total adult equivalents	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,537	1,527	1,514	1,506	1,502	1,501	1,500	1,499
Weaner heifers retained	249	236	217	207	200	198	197	196
Total breeders mated	642	643	642	642	640	639	638	637
Total breeders mated & kept	535	544	555	562	566	568	569	569
Total calves weaned	498	507	518	525	529	530	531	532
Weaners/total cows mated (%)	77.60	78.83	80.62	81.79	82.64	82.98	83.27	83.53
Weaners/cows mated and kept (%)	93.19	93.19	93.28	93.35	93.41	93.43	93.44	93.45
Overall breeder deaths (%)	4.53	4.53	4.52	4.53	4.56	4.57	4.58	4.59
Female sales/total sales (%)	47.79	47.92	48.08	48.16	48.20	48.21	48.22	48.22
Total cows and heifers sold	210	215	221	225	227	228	228	228
Maximum cow culling age	13	13	13	13	13	13	13	13
Heifer joining age	2	2	2	2	2	2	2	2
Weaner heifer sale & spay (%)	0.00	6.98	16.03	21.17	24.23	25.20	25.87	26.29
One year old heifer sales (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Two year old heifer sales (%)	58.48	52.48	52.48	52.48	52.48	52.48	52.48	52.48
Total steers & bullocks sold	230	233	239	242	244	244	245	245
Maximum bullock turnoff age	2	2	2	2	2	2	2	2
Average female price	$750.50	$710.13	$659.64	$631.26	$614.35	$608.98	$605.28	$602.99
Average steer/bullock price	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62

The key points to recognise about the values in Table 65 are:

- The optimal culling strategy (i.e. the most profitable strategy) was replaced with one that culls additional surplus heifers as weaners. This caused about the same number of 2 year old heifers to be culled prior to mating over time but increased the number of weaner heifers to be culled to maintain the same grazing pressure as herd reproduction efficiency improved.

- The impact on the reproduction efficiency of the herd of this strategy was that about the same number of cows mated over time achieved an increasing number of weaners.
- The total number of cattle sold increased over time but the average value of the females sold reduced. This reflected the increased proportion of less valuable females in the female sale mix.
- It still took 13 years for the predicted increase in the percentage of weaners produced from cows mated to reach the target.
- Even though more cattle were sold, and the number of weaners produced increased, the economic efficiency of the herd was significantly reduced. This demonstrates that strategies that do not maintain the optimum herd structure often reduce economic performance compared to the 'without change' scenario.

Table 66 indicates the marginal returns arising from incurring the bull changeover costs ($55,000) at the start of the investment period and selling weaner heifers to increase weaner numbers.

Table 66 Marginal returns for investment in genetically different bulls to improve fertility with the sale of additional heifers as weaners (Cull heifers for more weaners; Scenario 2)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
NPV of "Change" advantage	-$191,866
Annualised NPV	-$12,481
Peak deficit (with interest)	-$528,080
Years to peak deficit	n/a
Payback year	n/a
Payback period (years)	n/a

5.5.2.3 *What if the herd had a lower starting reproduction efficiency? (Scenario 3)*

The starting level of reproduction efficiency affecting the potential benefits has been raised as an issue by industry commentators. Some breeding herds have a lower starting reproduction efficiency than the median identified in the CashCow project for the Fitzroy region (McGowan *et al.* 2014). This was addressed by constructing a herd model for the Fitzroy region that applied the 25th (or 75th) percentile performance identified in the CashCow project to represent a breeding herd that performed at about the level of performance of the bottom quarter of herds surveyed. Table 67 shows the 25th (75th) percentile data applied in the models. This was used to construct a herd model with lower reproduction efficiency with all other parameters maintained at the same level in the base herd model.

Table 67 25th (75th) percentile reproduction performance for Central Forest data (McGowan et al. 2014)

Factor	Heifers	First lactation cows	Second lactation cows	Mature	Aged	Overall
P4M* (%)		33	56	55	55	52
Annual pregnancy (5)	75	67		79	71	79
Foetal / calf loss# (75th Percentile) (%)	17.7	11.3		8.5	11.8	10.2
Contributed a weaner (%)	48	67		70	68	69
Pregnant missing (%)		16.6		10.7	9.2	11.2

*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
***Calf loss percentages were determined in the Cash Cow 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. By definition, foetal and calf loss as it was derived excludes cow mortality.
^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.

Foetal/calf loss was retained at the 75th percentile value identified by the CashCow project although no relationship between low conception rates and high rates of calf loss was identified in the CashCow project report. This make the weaning rate calculated by our model (65%) substantially lower than the 'contributed a weaner' value (69%) identified by the CashCow project for the 25th percentile level of herd performance. Our model has a significantly lower starting level of reproduction performance than that indicated for the 25th percentile by the CashCow data for the region.

The herd model maintained the same overall culling and sale strategy when optimised. In this case only 4% of 2 year old heifers were culled prior to mating, a reflection of the lower starting reproduction efficiency of the herd. Cows were still culled on pregnancy status at weaning and age. Table 68 indicates the change in herd structure as the conception rate changed for each female cohort.

Table 68 Modelled steps in genetic change of weaning rate and herd structure with 25th percentile starting point (Lower starting reproduction rate; Scenario 3)

Factor	25th base	Year 4	Year 6	Year 8	Year 10	Year 12	Year 13
Total adult equivalents	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,522	1,525	1,527	1,528	1,528	1,528	1,528
Weaner heifers retained	238	242	242	243	243	243	243
Total breeders mated	738	719	700	690	685	681	680
Total breeders mated & kept	552	550	550	550	550	550	550
Total calves weaned	485	484	485	485	485	486	486
Weaners/total cows mated (%)	65.78	67.24	69.27	70.32	70.91	71.26	71.37
Weaners/cows mated and kept (%)	87.89	87.89	88.14	88.24	88.26	88.26	88.26
Overall breeder deaths (%)	4.47	4.47	4.45	4.46	4.48	4.49	4.50
Female sales/total sales (%)	47.69	47.66	47.68	47.68	47.67	47.66	47.65
Total cows and heifers sold	204	203	204	204	204	204	204
Maximum cow culling age	13	13	13	13	13	13	13
Heifer joining age	2	2	2	2	2	2	2
Weaner heifer sale & spay (%)	2.07	0.00	0.00	0.00	0.00	0.00	0.00
Two year old heifer sales (%)	28.71	31.69	40.27	44.33	46.41	47.38	47.59
Total steers & bullocks sold	224	223	223	224	224	224	224
Maximum bullock turnoff age	2	2	2	2	2	2	2

Table 69 indicates that, due to the trade-offs occurring, economic performance was not improved with investment in genetic improvement of fertility in a Fitzroy NRM herd with lower starting reproduction efficiency: 65% weaning rate cf. 77% as assumed for Scenarios 1 or 2.

Table 69 Marginal returns for investment in genetically different bulls to improve breeder fertility with 25th percentile reproduction performance for Central Forest data (McGowan et al. 2014); (Lower starting reproduction rate; Scenario 3)

Factor	Value
Period of analysis	30
Interest rate for NPV	5.00%
NPV of "Change" advantage	-$48,857
Annualised NPV	-$3,178
Peak deficit (with interest)	-$131,101

Years to peak deficit	n/a
Payback period (years)	n/a
IRR of "Change" advantage	-6.47%

5.5.2.4 What if the bull change over costs were not incurred? (Gradual replacement, same cost; Scenario 4)

Table 70 shows the incremental increase in conception rates over the first five mating's as the genetically different bulls were introduced. Heifers with and without the different genes had the same chance of being culled prior to mating. All mated females that did not show as pregnant at weaning were culled. It was Year 8 before the first lot of heifers produced by a completely changed over bull herd were mated and produced calves.

Table 70 Incremental steps in genetic change of conception rate with bulls replaced over time (Gradual replacement, same cost; Scenario 4)

Parameter	First mating	Second Mating	Third mating	Fourth mating	Fifth mating
Total herd bulls	22	22	22	22	22
Bulls with different genes	4	9	13	18	22
Mature cows mated to different bulls	126	251	377	503	
Number that conceive	109	219	324	423	
Number that wean a calf	103	206	305	398	
Heifer weaners produced	51	103	153	199	
Yearling heifers	50	100	148	193	
Two year heifers pre culling	48	97	143	187	
Heifers with different genes mated	30	60	88	115	
total heifers mated	144	144	144	144	
Percentage of heifers with different genes	20.6%	41.3%	61.2%	80.0%	100%
Improvement in conception rate of mated heifers	1.2%	2.5%	3.7%	4.8%	6.0%
Improvement in conception rate of 3-4 year heifers		1.2%	2.5%	3.7%	4.8%
Improvement in conception rate of 4-5 year cows			1.2%	2.5%	3.7%
Improvement in conception rate of 5-6 year cows				1.2%	2.5%
Improvement in conception rate of 6-7 year cows					1.2%
Year of impact	Year 4	Year 5	Year 6	Year 7	Year 8

Table 71 shows the change in herd structure over the 17 years taken to implement the strategy. The same impact on herd structure as shown in Table 63 was repeated in Table 71, but at a slower rate.

Table 71 Modelled steps in genetic change of weaning rate and herd structure with bulls replaced over time (Gradual replacement, same cost; Scenario 4)

	Base	Year 4	Year 5	Year 6	Year 7	Year 8	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17
Total adult equivalents	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,537	1,537	1,537	1,537	1,538	1,538	1,539	1,539	1,539	1,539	1,539	1,540	1,540
Weaner heifers retained	249	249	249	249	249	250	250	250	250	250	250	250	250
Total breeders mated	642	640	637	632	626	620	608	605	603	601	599	598	598
Total breeders mated & kept	535	535	535	535	535	535	535	535	535	535	535	535	535
Total calves weaned	498	498	499	499	499	499	500	500	500	500	500	500	500
Weaners/total cows mated (%)	77.60	77.86	78.33	78.94	79.68	80.50	82.19	82.59	82.93	83.23	83.46	83.61	83.70
Weaners/cows mated and kept (%)	93.19	93.19	93.20	93.22	93.24	93.28	93.38	93.41	93.42	93.44	93.45	93.45	93.46
Overall breeder deaths (%)	4.53	4.53	4.53	4.53	4.52	4.53	4.55	4.56	4.57	4.58	4.58	4.59	4.59
Female sales/total sales (%)	47.79	47.79	47.80	47.80	47.80	47.80	47.79	47.78	47.78	47.77	47.77	47.77	47.76
Total cows and heifers sold	210	210	210	210	211	211	211	211	211	211	211	211	211
Maximum cow culling age	13	13	13	13	13	13	13	13	13	13	13	13	13
Heifer joining age	2	2	2	2	2	2	2	2	2	2	2	2	2
Two year old heifer sales (%)	58.48	58.18	58.59	59.43	60.56	61.89	66.33	67.18	67.79	68.24	68.52	68.67	68.75
Total steers & bullocks sold	230	230	230	230	230	230	230	230	230	231	231	231	231
Average female price	$750.50	$750.50	$750.66	$750.93	$751.28	$751.70	$752.75	$752.95	$753.10	$753.21	$753.27	$753.31	$753.33
Average steer/bullock price	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62	$812.62

Table 72 indicates that even though no additional costs were incurred, the strategy only produced a minimal $685 annualised NPV over the 30 year investment horizon.

Table 72 Marginal returns for investment in genetically different bulls to improve breeder fertility with no additional costs (Gradual replacement, same cost; Scenario 6)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
NPV of "Change" advantage	$10,537
Annualised NPV	$685
Peak deficit (with interest)	-$898
Years to peak deficit	6
Payback period (years)	9

5.5.2.5 Summary and discussion of results

The marginal returns from the genetic change of fertility were negative where additional capital was required to replace the bull herd: annualised NPV for the net cash flow for the genetic change of fertility of the breeder herd was -$3,265 at a starting weaning rate of 77% and -$3,178 at a starting weaning rate of 65%. Gradually introducing bulls with different genes for fertility with no additional costs produced a negligible change in returns. It is possible in the Fitzroy region that some minor benefits may be gained by a reduction in the cow culling age as the conception rates change due to a freeing up of some livestock capital. The sale of more valuable cull heifers would need to be forgone for this to happen and any anticipated benefits may prove illusionary.

Where herd bulls were replaced over time, any costs incurred to segregate and select heifers produced by the genetically different bulls would need to be very low, as the benefits associated appear unlikely to be large. For example, the herd gross margin in Year 17 for the genetically different herd improved by about 1.3% or $3,156 per annum compared to the base herd. This benefit was partly offset by the herd asset value falling by $3,597 in the same year due to the structural change in the herd. Bringing forward a less than 2% improvement in gross margin by a couple of years, that is largely offset by a fall in the asset value of the herd, and incurring costs in doing so seems unlikely to significantly change the outcome.

The economic and financial analysis reported here indicated that selecting for livestock with different genes for fertility is likely to have variable impacts and unexpected outcomes. An example of an unexpected outcome was the fact that the breeding herd did not produce more weaners while gradually improving reproduction efficiency but reduced the number of cows mated to produce the same number of weaners over time. This outcome was related to maintaining the most profitable culling strategy and sale strategy as the reproduction efficiency of the herd improved. Changing the strategy to cull additional heifers as weaners to produce more calves caused profit to fall further even though reproduction efficiency improved by the same amount as previously.

There is often a temptation, based on limited analysis, to suggest a rule of thumb concerning the level of herd reproduction efficiency where chasing genetic improvement in fertility is unlikely to provide economic benefits. We have not been able to discern a clear break-even point in our analyses between the level of herd reproduction efficiency and the level of economic benefit. For example, when the weaning rate was reduced from 77% to 65%, and there was still capacity to cull all non-pregnant females, economic benefits were still negative: -$3,265 cf. -$3,178, respectively.

After having considered the current analysis and similar exercises undertaken in earlier times, we have identified what we think are the key factors underpinning the economic results:

- Where there is a requirement to retain non-pregnant females to maintain breeder numbers, improving herd reproduction efficiency will likely improve herd output as each additional pregnant breeder effectively replaces a non-pregnant breeder held to maintain breeder numbers.
- Once herd performance is at a level where culling all non-pregnant breeders is possible, measureable economic benefits appear unlikely for even the most beneficial implementation scenarios. Any improvement in reproduction efficiency above this level of performance causes replacement of cull cows with cull heifers or vice versa due to the limit placed on total grazing pressure applied by the AE cap.
- The point where all non-pregnant cows can be culled in any breeding herd can be determined by expected mortality rates, the final age of culling breeders, the optimal age to cull replacement heifers and the optimum age to sell steers. The optimum culling or selling

age can also be determined by the relative sale values of the various classes of sale stock and these relativities can change over time.

- Another complicating factor is that many northern breeding herds have their performance limited by the level of phosphorus deficiency of the land types being grazed and appropriately managing the phosphorus status of the herd may lift herd performance to a level where finding benefits for also genetically improving fertility may become very challenging.

Appropriately linking an effective livestock production model to a partial budgeting process that can follow the impacts of change over a number of decades is the critical component that provides insight into the value of improving reproduction efficiency. This insight cannot be derived from a less capable framework that does not capture all aspects of performance and costs relating to each component of the herd and the trade-offs that occur over time when the performance of one component of the herd is changed.

Typical self-replacing beef production systems in northern Australia have (at least) a breeding activity that produces weaners, heifer growing activities that supply replacement breeding females and cull heifers for sale, a number of steer growing and finishing activities and a cull cow activity that may or may not hold cull cows for a season or longer periods of time. The suitable age to cull breeding females and replacement heifers, or sell steers, or the period of time to hold cull cows prior to sale, are some of many factors that have to be considered prior to estimating the value of changing the performance of part of the herd.

The starting herd performance and the herd structure that optimises returns both need to be identified prior to modelling the value of genetically changing the conception rates of the breeding component of the herd. The modelling process also needs to be able to accurately follow the changes in herd structure and herd numbers that occur as a change in herd management is implemented. This is critically important where change takes decades to flow through a herd. Failure to incorporate the aspects of time and risk in the analysis of the costs and benefits of changing the performance of a breeding herd in northern Australia largely negates the value of the analysis.

The components required to make a genetic selection program effective on an extensive cattle station in northern Australia have complex interactions and may require a complete rethinking of the current herd management strategy and property operations. Furthermore, the potential benefits should ideally be examined on a property by property basis to account for the property-specific details in terms of location, operational size, land capability, climate, herd performance and existing management practices.

5.5.3 Investing to reduce foetal/calf loss

This scenario identifies the parameters of an investment to reduce foetal/calf loss in heifers and first lactation cows.

The Cash Cow project (McGowan et al 2014) identified median values of 10.2% foetal/calf loss in heifers and 7.3% in first lactation cows for the Central Forest. These losses occurred sometime between conception (pregnancy testing) and weaning and have been applied in the construction of the "without change" or base herd model. Calf loss percentages were determined in the Cash Cow 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 Cash Cow project, excludes cow mortality during the same period and subsequent calf loss due to that source.

Table 73 Median reproduction performance for Central Forest data (McGowan et al 2014)

	Heifers	First lactation cows	2nd lactation cows	Mature	Aged	Overall
P4M*		49%	64%	77%	71%	68%
Annual pregnancy**	80%	78%		89%	86%	85%
Foetal / calf loss	10.20%	7.30%		5.90%	4.90%	6.70%
Contributed a weaner^	67%	71%		80%	86%	77%
Pregnant missing#		11.80%		6.60%	6.30%	7.90%

The Cash Cow project undertook multivariable modelling to identify the major drivers of foetal/calf loss and to explain the effect of each factor after adjustment for all other factors in the model. The absolute difference was expressed in terms of percentage point's increase or decrease i.e., the difference between 50% and 55% is 5 percentage points. The modelling identified the following factors as affecting the percentage of foetal/calf losses:

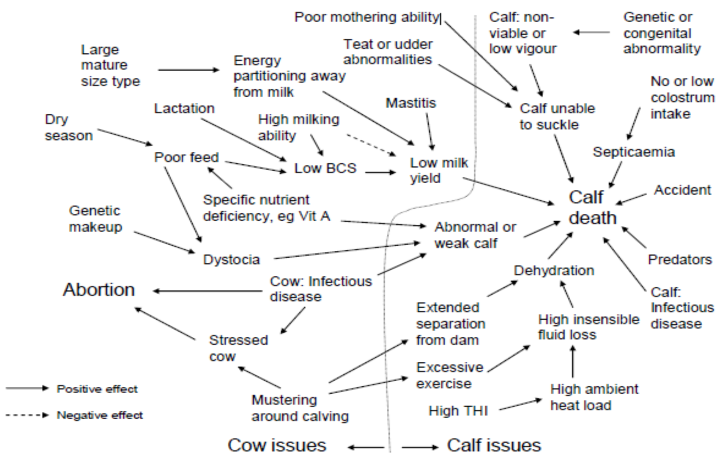
- Confirmed pregnancy to weaning loss was 3.6 percentage points higher in cows that lactated than those that did not lactate in the previous year.
- Tall cows lost on average 3.7 percentage points more pregnancies before weaning than short cows, with moderate-height cows intermediate. The difference between tall cows and others was significant but was not significant between short and medium height cows.
- In situations where the risk of phosphorous deficiency was low (≥500 mg/kg ME), overall foetal/calf loss was 3.4 percentage points lower than where the risk of phosphorous deficiency was high.
- Where phosphorous was <500 mg/kg ME, cows with a body condition score of >3 (range 1-5) at the PD muster had 3 percentage points lower foetal/calf loss than cows in lower body condition.
- Where phosphorous was ≥500 mg/kg ME, cows with a body condition score of >3.5 had on average 9 percentage points lower foetal/calf loss than cows in body condition scores of 2.5-3.5 ($P<0.05$).
- Foetal/calf loss can be reduced by at least 3 percentage points if cow nutrition is sustained at an adequate level, as reflected by a body condition score above 3 at time of calving.
- Losses in situations where mustering efficiency is <90% were 9 percentage points higher than where mustering efficiency was >90%.
- Predicted impact of mustering within two months of calving x cow age class interaction. When cows were not mustered around calving, foetal/calf loss was only, on average, 1.3

percentage points higher in first-lactation cows than in older cows. In mature cows, foetal/calf loss was increased by 2.5 percentage points if they were mustered around calving

- Back fitting the final model showed that where property owners/mangers considered wild dogs were adversely impacting on herd productivity, whether control was being attempted or not, foetal/calf loss was predicted to be 5-7% higher than where wild dogs were not considered to be adversely affecting productivity
- Back fitting the final model also demonstrated that inadequate average dietary protein status (CP:DMD of <0.125) during the dry season was associated with about 4.2 percentage points higher loss compared to that for females with an adequate dietary protein status.
- In mobs where there was a high prevalence of recent Bovine Viral Diarrhoea Virus infection detected at either the time of pregnancy diagnosis or at the wet/dry muster there was a significantly higher percentage of foetal/calf loss than in mobs with a low prevalence of recent infection
- Leptospirosis - there was no evidence that either L.hardjo or L.pomona infection was significantly associated with foetal/calf loss in the study. Further, back fitting of vaccination against leptospirosis to the final model showed a reduction in foetal/calf loss of 3.4 percentage points.
- Mobs where the prevalence of samples positive for antibodies to C.fetus sp.veneralis (causes Vibriosis) was high, percentage foetal/calf loss was significantly higher than in mobs where the prevalence was low to moderate.
- Other factors:
  - Proportion of the paddock grazed within 2.5 km of water.
  - No disease vaccination variable had a significant effect.
  - Herd size did not significantly affect loss, but the trend was for herd's greater than 1000 to have lower losses.
  - Genotype, which could vary between Bos indicus and Bos Taurus, was not associated with foetal or calf loss.
  - Month of calving between July of one year and June of the next did not have a significant effect. However, back fitting this variable showed a trend for highest loss when calving occurred in April-June, and lowest loss when calving in October-November (range of effect was 3.4%)

The Cash Cow project developed a possible causal pathway for calf loss. (Figure 15)

Figure 15 Possible causal pathway for foetal and calf loss in northern Australia (McGowan et al 2014)



If a relatively high value for loss in any age class of females was identified, the property manager would need to work through the factors likely to affect calf/foetal loss in their herd based on the modelling of the Cash Cow project and the causal pathways identified in Figure 15. From there an analysis based on the identified cause and effect pathway could proceed.

The wide range of possible agents and combinations of agents identified by the Cash Cow project together with a lack of other research data indicating a "typical" cause and effect relationship for our beef enterprise limits the identification of appropriate examples for analysis and requires us to rephrase the question in two ways.

Firstly, the question is rephrased to look at what level expenditure could be incurred on a per head per annum basis to resolve a calf loss problem. The first question is - "if $5, $7.50 or $10 was spent per head and calf/foetal loss in first calf and second calf cows was reduced by half, what would be the return on the funds spent?"

The Cash Cow project (McGowan et al 2014) also identified that additional capital costs could be required to address the problem of calf/foetal calf loss. They identified "Increasing levels of cattle control that enable higher levels of husbandry—such as effective fencing, good paddock design, appropriate segregation, training of cattle, and selection for temperament—may substantially reduce foetal/calf loss". So, secondly, the question can also be "what amount of upfront capital could be spent to reduce calf mortality in first and second calf heifers by 50% on this property?"

To answer these questions the base herd model was modified and optimised by:

- Halving the calf loss values for the first calf heifers (2 to 3 year old females) and the first lactation cows (3-4 year old females).
- Calculating the new weaning percentage and the new number of sales after mating.
- Balancing the herd structure for the new level of reproduction efficiency and selling any surplus heifers in the 2-3 years age group.

The data from the new steady state herd model with 50% lower rates of calf loss in young 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 model. This reflected the expectation that a one year (minimum) lag between expenditure and receipt of benefits would be expected for any strategy aimed at improving calf/foetal loss.

The treatment cost allowance 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 “without change” and the “with change” models were compared to identify the marginal returns achieved. Table 76 records the results of partial investment analyses at cost levels of $5, $7.50 and $10 per young female treated plus upfront capital expenditure of $20,000, $30,000 and $40,000.

Table 74 Investment analysis of a 50% reduction in calf loss in heifers and first lactation cows

Expenditure	Period of analysis (years)	Marginal NPV @ 5%	Annualised return	Peak deficit	Years to peak deficit	Payback period (years)
$5 /head	30	$7,289	$474	-$1,829	4	6
$7.50 /head	30	-$6,427	-$418	-$17,502	never	never
$10 /head	30	-$20,142	-$1,310	-$55,927	never	never
$20,000 capital	30	$15,672	$1,019	-$20,000	1	12
$30,000 capital	30	$6,148	$400	-$30,000	1	n/a
$40,000 capital	30	-3,376	-$220	-$40,451	3	n/a

It would appear that no more than $5 per head should be spent on reducing calf/foetal loss by 50% in the heifers and first lactation cows if a return on the funds invested was being sought. Even then, a successful treatment would only increase enterprise profit by about $500 per annum over the longer term.

Spending more than $7.5 per treated female or gaining a reduction in calf loss of less than 50% in the classes of female treated would make any investment unlikely to produce a positive return on funds invested.

For this size of herd and enterprise, expenditure of up to $20,000 as upfront capital expenditure with no additional ongoing expenses appears worthwhile of further consideration on the basis that calf foetal loss in the two classes of females is reduced by at least 50%.

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 affect the benefits arising from applying per head treatment costs - only by the current level of herd productivity and the change in herd productivity realised would affect 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 Table 76.

5.5.4 Wet season pasture spelling for breeders

Compiled by Tim Moravek (DAF Rockhampton)

This scenario describes the economic outcome of adopting wet season spelling on the optimised female sales herd. It assumes that the base herd is sustainably stocked and a wet season spell is added to the management of all breeders.

The project *Spelling Strategies for recovery of pasture* condition (Jones et al 2016) identified a number of performance measures related to herd performance from GRASP (Littleboy and McKeon 1997). The key performance indicators that have been used to adapt the baseline Fitzroy scenario come from the "Bon Accord" scenario described in the spelling project (Jones et al 2016). The optimised sales base file was configured with the relative difference to the breeders only. The benefits of wet season spelling were introduced after 10 years. It should be noted that this is an assumption that wet season spelling will eventually lead to improvement in land condition. There is some debate as to the length of time required for wet season spelling to improve land condition, with Jones (2016) noting "the results over a five year project life did not produce the significant differences expected in land condition that most Grazing Land Management recommendations imply". Therefore, in the Spelling project, GRASP modelling and animal production modelling was extended to decadal timeframes and results are as shown below.

Table 75: Performance Indicators from "Spelling Strategies for recovery of pasture condition" (Jones et al, 2016)

Scenario /Average variable	Mortalities	Weaning Rate	Average LWG/AE/annum
Base	7.5%	66%	103kg
Wet Season Spelling	7.3%	69%	109kg
Relative Difference	-0.2%	3%	6 kg

*note: average live weight gain was obtained from the authors for this exercise.

Because of implementing wet season spelling, one noticeable impact on the herd, which affected the production system, was the increase in the weight of the breeders, although minor, still affected the number of breeders able to be carried at the same AE rating across the entire property. In order to maintain the same AE's as the base level, excess calves had to be sold (there was literally no space to cull more cows from the already high productivity cow herd in the base file).

Two other options were available. The first was to sell additional male cattle at a younger age. As steers are generally the profit centre, this was not likely to produce a favourable outcome and would also require a significant revamp of the paddocks, particularly as the steer paddocks were not being spelled. The other option was to reconfigure breeder paddocks which was an unknown and unquantifiable proposition for this example.

Since it is unclear what configuration the base herd for the scenario property is in, the first assumption is that it will cost nothing to implement wet season spelling. As unlikely as this is to be the case, it does give an indication as to whether anything could be invested to implement wet season spelling. The results are shown in Table 76 below.

Table 76: Results for Investment analysis of wet season spelling

Factor	Value
Interest rate for NPV	5.00%
NPV of "Change" advantage	-$21,375
Annualised return (profit/year for analysis period)	-$1,715
Period of analysis (10 years or 20 years)	20*
Peak deficit (with interest)	-$56,715

Year of peak deficit	2036
Payback year	na
Payback period (years)	na

* Note this analysis is undertaken over a twenty year investment period

The results show that it is unprofitable for this property to take on wet season spelling – even at no additional cost. This result is unexpected and surprising since with marginally less mortalities, higher weaning rate and higher liveweight gain it should follow that the wet season spelling herd is more profitable. However, this demonstration illustrates two important considerations for the economics of cattle reproduction and beef production. The first is that by taking a more profitable turn off option (in this case, cull cows) and effectively replacing them with a lower margin animal (a calf), due to higher breeder productivity, can have perverse outcomes. The second is that there is diminishing returns on improvements. It is clear from this example that taking the weaning rate from 77% to 80%, even if it costs nothing, is not worth doing in this scenario.

Due to this result, further analysis on investment thresholds was not undertaken since there is no extra money to spend to implement wet season spelling.

5.5.5 Improving performance in low Phosphorus (P) status breeder herds

Phosphorus deficiency results in poor appetite and feed intake, poor growth, reduced fertility, milk production, bone breakage and, in severe cases, bone deformities. Added to this poor performance is an increased risk of deaths from botulism when cattle chew bones in their craving for the mineral.

The alternatives modelled were "without change" properties that run breeder herds with different levels of P status with no effective supplements and the same property with the same starting P status but with supplements fed to breeders. These are different base scenarios to the previously applied "without change" herd model although the steers and heifers grazed the same land types post weaning as previously and do not require supplements and, after a period of compensation, achieve the same growth path and sale weights.

In summary, only the breeders graze country with the different levels of P deficiency and all stock post weaning ran on the same buffel country as in previous scenarios until sale. Heifers were mated on buffel and then went onto the P deficient country to calve.

A range of P status breeder herds was modelled with and without supplements. The status levels and expected response to supplements for each herd were based on the categories of (McCosker and Winks 1994) and the MLA phosphorus management book (Jackson et al 2012) and as modified by Rob Dixon (pers. comm.)

Table 77 Categories of P deficiency (soil P (ppm)) from 1994, 2012 'Phosphorus books' and R Dixon*

Category	McCosker and Winks (1994) definition	Jackson et al. (2012)	Modified ranges Dixon (2018 pers. comm.) Category	(Soil P in ppm)
			Very severely deficient[#]	<=2
Acute	<2	<4	Acute	2-3
Deficient	3-5	5	Deficient	4-5
Marginal	6-8	6-8	Marginal	6-8
Adequate	>8	-	Adequate	>8

*Note that 2012 definition of 'Acute' and 'Deficient' was modified due a change in the capacity to detect low soil P (<4). Rob Dixon has modified the 2012 definition applied in the Phosphorus book based on extensive research and changes in technology and we have used his suggested modified ranges for P deficiency in our analysis.

[#]Very severely deficient relates to extreme situations of P deficiency found in parts of South Africa and reported in the literature and research work undertaken in pens to look at extremes of P deficiency. Rob Dixon believes this situation would not be representative of many locations in Australian grazing lands and hence should not be examined in the scenario analysis for the Fitzroy.

This analysis will attempt to identify the impact of feeding:

- Phosphorus (P) supplements fed in the wet season alone (Wet season P);
- Nitrogen (N) and Phosphorus (P) supplements fed in the dry season alone (Dry season N +P); or
- Phosphorus (P) supplements fed during wet and dry seasons and combined with N supplements during the dry season (Dry season (N +P), Wet season P).

These supplements were fed at varying rates to breeders grazing country with each category of P status identified in Table 77 previously. Table 78 indicates the supplementation treatments considered in the analysis. The supplementation treatments do not include the feeding of dry season protein supplements and these will be included at a later time in a separate analysis.

Table 78 Treatments for supplementation strategies

Treatment	P status of country	Supplement strategy
1	Marginal	No supplement

2	Marginal	Wet season P
3	Marginal	Dry season N +P
4	Marginal	Dry season (N +P), Wet season P
5	Deficient	No supplement
6	Deficient	Wet season P
7	Deficient	Dry season N +P
8	Deficient	Dry season (N +P), Wet season P
9	Acute	No supplement
10	Acute	Wet season P
11	Acute	Dry season N +P
12	Acute	Dry season (N +P), Wet season P

Table 79 identifies the main components of the supplements fed in the various scenarios.

Table 79 Supplement loose lick composition (as-fed basis[A]) and cost per tonne for a Fitzroy region, with different levels of phosphorus (P) status

Supplement	Wet season P lick (Marginal, Deficient and Acute P herds)	Dry season N +P lick Marginal P herd	Dry season N +P lick Deficient P herd	Dry season N +P lick Acute P herd
Urea (g/kg)	0	300	300	300
Ammonium sulphate (GranAm), (g/kg)	0	80	80	80
Copra meal (g/kg)	0	100	100	100
Calcium phosphate (Kynofos), (g/kg)	800	60	120	170
Salt (g/kg)	200	460	400	350
Crude protein (g/kg)	0	985	985	985
P (g/kg)	168	13.1	25.7	36.2
Supplement cost including freight ($/t)	$1,309	$835	$888	$932

[A]The expected dry matter content of minerals and copra meal was ca. 970 and 900 g/kg, respectively

Table 80 identifies the expected rate of intake for each level of P status and combination of supplements. Each mix, when appropriately fed, will meet the rate of intake targeted.

Table 80 Supplement and nutrient intakes for breeders supplemented with mineral loose lick supplements in the wet and/or dry season containing nitrogen (N) and/or phosphorus (P) for scenarios covering Marginal, Deficient and Acute P status land types

Scenario	Supplement intake (g/head /day)		Crude protein intake (g/head /day)		P intake (g/head /day)	
	Wet	Dry	Wet	Dry	Wet	Dry
1. Marginal herd, No supplement	0	0	0	0	0	0
2. Marginal herd, Wet season P	20	0	0	0	3.4	0
3. Marginal herd, Dry season (N +P)	0	155	0	153	0	2
4. Marginal herd, Dry season (N +P), Wet season P	20	155	0	153	3.4	2
5. Deficient herd, No supplement	0	0	0	0	0	0
6. Deficient herd, Wet season P	60	0	0	0	10.1	0
7. Deficient herd, Dry season (N +P)	0	155	0	153	0	4
8. Deficient herd, Dry season (N +P), Wet season P	60	155	0	153	10.1	4
9. Acute herd, No supplement	0	0	0	0	0	0
10. Acute herd, Wet season P	81	0	0	0	13.6	0
11. Acute herd, Dry season (N +P)	0	155	0	153	0	5.6
12. Acute herd, Dry season (N +P), Wet season P	81	155	0	153	13.6	5.6

The dry season supplements were based on supplying 150 g crude protein/head /day. The Kynofos percentage was adjusted in the supplements to achieve the target P intake for the different scenarios. The same wet season supplement was used for all scenarios but the supplement intake was adjusted to achieve the target P intake for the different P status scenarios. The feeding periods of the supplements were also adjusted so that appropriate P was fed in total at each level of P status. Table 81 identifies the cost of the various supplements per head per annum.

Table 81 Supplement feeding cost

Status	Supplement strategy	Days supplement fed		Seasonal feeding cost ($/breeder)		Total feeding cost ($/breeder/annum)
		Wet	Dry	Wet	Dry	
Marginal	No supplement					
Marginal	Wet season P	150		$3.93		$3.93
Marginal	Dry season (N +P)		120		$15.53	$15.53
Marginal	Dry season (N +P), Wet season P	150	90	$3.93	$11.65	$15.58
Deficient	No supplement					
Deficient	Wet season P	150		$11.78		$11.78
Deficient	Dry season (N +P)		150		$20.65	$20.65
Deficient	Dry season (N +P), Wet season P	150	120	$11.78	$16.52	$28.30
Acute	No supplement					
Acute	Wet season P	150		$15.90		$15.90
Acute	Dry season (N +P)		180		$20.65	$20.65
Acute	Dry season (N +P), Wet season P	150	150	$15.90	$21.67	$37.57

Prices include freight to the property and are GST exclusive. Supplement composition and nutrient intakes are on “as fed” basis. No allowance was made for additional feeding out costs potentially associated with each supplement feeding regime as the assumption was made they could be distributed as part of normal herd management operations.

Table 82 shows the expected level of response to the supplement programs applied to each level of P status. Reference was made to existing data and publications as well as the expert opinion of and QAAFI and DAF staff, particularly R. Dixon and M. Sullivan to assign biological responses to each of the supplement regimes.

Table 82 Estimated response to phosphorus (P) supplementation strategies for breeding herds grazing land types either Adequate, Marginal, Deficient or Acutely deficient in P

Parameter	P status of grazing land/breeders			
	Adequate	Marginal	Deficient	Acute
Average cow LW (kg)				
1. No P or N (baseline)	460	450	435	428
2. Wet season P	460	460	450	445
3. Dry season N+P	460	460	445	435
4. Dry season N+P, wet season P	460	460	455	450
Cull cow LW in June (kg)				
1. No P or N (baseline)	440	430	410	400
2. Wet season P	440	440	425	418
3. Dry season N+P	440	440	420	412
4. Dry season N+P, wet season P	440	440	430	425
Breeder mortality rate (%)				
1. No P or N (baseline)	2	4	6	9
2. Wet season P	2	2	4	5
3. Dry season N+P	2	2	4	5
4. Dry season N+P, wet season P	2	2	3	3
Weaning rate (%)				
1. No P or N (baseline)	77	72	67	57
2. Wet season P	77	77	73	72
3. Dry season N+P	77	77	72	67
4. Dry season N+P, wet season P	77	77	75	73
Weaner LW at 6 months (kg)				
1. No P or N (baseline)	200	190	175	168
2. Wet season P	200	200	190	180
3. Dry season N+P	200	200	190	180
4. Dry season N+P, wet season P	200	200	195	190

A key assumption was that although P was the major factor limiting breeder performance at each level of P status, the supplementation program did not return breeder herd performance to the level of “Adequate” due to other nutritional constraints expected to be associated with country with each level of P status. Cull cows were expected sell at the weights nominated for each level of P status and supplement. The weights shown are paddock weights and were reduced by 5% (uniformly) to calculate weight at the point of sale.

Table 82 also identifies the expected reduction in average weaning rate and weaner weight at six months of age for each level of P status and supplementation. In this analysis, it was assumed that weaners would compensate for the lower weaning weight by the time of sale and cull heifers and 2-3 year old steers would sell at the same average weight in all scenarios.

Tudor and O'Rourke (1980) found that compensatory gain effects (increased growth rate of restricted cattle when grazed on good quality pasture from 200 days of age) overcame the effects of highly restricted diets prior to weaning. Growth rates were 48% higher compared to calves that were on a high plane of nutrition prior to weaning. This indicates that weaners from low P status herds are likely to compensate sufficiently to achieve the same growth path as weaners from adequate P status herds within six months post weaning as long as they both have access to the same level of improved nutrition post weaning.

Therefore, the differences in weaning weight shown in Table 82 had no impact on the final sale weights of steers and cull heifers in this analysis. Producers who sell weaners directly off cows with a low P status would need to incorporate the expected impact on weaning weights in their calculation of the benefit of supplementation. Differences in pre-weaning growth rates expected in herds with different P status and different levels of P supplementation were incorporated in the AE rating of stock up to 12 months of age in the respective herd models.

Table 83 shows the expected change in Body Condition Score (BCS) for cows grazing pastures with different levels of P status and no P or N supplementation. The change in BCS due to pregnancy and lactation at each level of P deficiency are a key driver of subsequent conception and mortality rates in each class of country and largely determine breeder herd performance.

Table 83 Expected weight loss and change in Body Condition Score (BCS) without supplementation

P status of country	Soil P (ppm)	Conceptus-free liveweight loss during pregnancy and lactation
		No P or N
Acute	2-3	80 kg (1.6 BCS)
Deficient	4-5	50 kg (1 BCS)
Marginal	6-8	25 kg (0.5 BCS)
Adequate	>8	12.5 (0.25 BCS)

In summary, all scenarios placed weaners back onto the same Brigalow country post weaning. They stayed there until they were either sold or mated. Heifers were first mated on the Brigalow country and then returned to the breeder herd. Given that weaners were expected to compensate the weight differences at weaning by the time they were sold or enter the breeding herd, the main impacts of the different levels of P status, breeder nutrition and supplements were on cull cow sale weights, breeder herd mortality rates and weaning rates.

Each supplementation scenario was modelled to include the impacts of implementing the change. Therefore, cows were fed the supplement in the first year, their reproduction efficiency and body weight did not begin to change until the second or subsequent years and the extra weaners produced by the supplement feeding program did not add to the returns of the property until they were sold. All responses to the feeding of supplements were implemented over the first five years of the analysis. Herd structures changed as reproduction efficiency and mortality rates changed, cows, and heifers were either culled or retained to maintain the same grazing pressure while adjusting to the new herd target.

5.5.5.1 Supplementing breeders in a Marginal P herd

Breeders in a marginal P herd without supplement had an average weight in the paddock of 450 kilograms, an average sale weight of 430 kilograms and a mortality rate of 4%. Table 84 indicates the reproduction, calf loss and mortality performance of the marginal P breeding herd without a supplement. Conception, mortality and calf loss rates combined to achieve an average weaning rate of 72.06%.

Table 84 Reproduction performance for a marginal P breeding herd without supplement

Parameter	Heifers	First lactation cows	2nd lactation cows	Mature	Aged
Conception rate	80%	69%	80%	80%	79%
Foetal / calf loss	10%	7%	6%	6%	5%
Mortality		4%	4%	4%	4%

5.5.5.1.1 Marginal P herd with P supplement in the wet only

The assumptions for the improvement applied in the wet P supplemented herd model were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 5% greater conception rates were achieved in the remaining breeders (77%),
- mortality rates fell from 4% to 2% in all breeder classes fed the supplement,
- Cull cows had 10 kilogram heavier live weights at sale (430kg →440kg) and were 10 kilograms heavier in the paddock on average (450kg →460 kg),
- steers and cull heifers achieved the same sale weights with or without the supplement,

Table 85 indicates the wet season P supplement costs incurred by the Marginal P herd. All other treatment costs and prices were identical on per head or per treatment in the “with” and “without” supplement models. The wet season supplement was fed to all breeding cows whether they were sold or retained.

Table 85 Wet season only supplement costs for the marginal P deficient herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum
Wet P supplement Marginal P cows	$1309	150	$3.93

The expenditure of a relatively small amount of funds to fix a Marginal P deficiency with a wet season only P supplement produced a moderate additional return. Doubling the cost of the supplement did not significantly reduce the additional benefits achieved. The benefit was attributable to the relatively large response in the conception rates and the halving of the mortality rate in breeders.

Table 86 Marginal returns to fixing a marginal P deficiency in breeders with wet P only

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$86,137
Annualised return (profit/year for analysis period)	$5,603
Period of analysis (years)	30
Peak deficit (with interest)	-$7,185
Years to peak deficit	3
Payback period (years)	3
IRR of "Change" advantage	114.38%

5.5.5.1.2 Marginal P herd with Dry season N +P supplement

The assumptions for the improvement applied in the Dry season N +P supplemented herd model were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 5% greater conception rates were achieved in the remaining breeders (77%),
- mortality rates fell from 4% to 2% in all breeder classes fed the supplement,
- Cull cows had 10 kilogram heavier live weights at sale(430kg →440kg) and were 10 kilograms heavier on average in the paddock (450kg→460kg),
- steers and cull heifers achieved the same sale weights with or without the supplement,

Table 87 indicates the dry season only N +P supplement costs incurred by the marginal P herd. All other treatment costs and prices were identical on per head or per treatment in the “with” and “without” supplement models. The dry season only supplement was only fed to breeding cows retained in the herd, a smaller number in total than was fed the wet P only treatment.

Table 87 Dry season only supplement costs for the marginal P deficient herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum
Dry season (N +P) supplement Marginal P cows	$835	120	$15.53

The feeding of the N +P dry season only supplement increased the net costs of feeding without any performance improvement above and beyond the feeding of wet season only P supplements alone. This is even though the cull breeders do not receive the supplement.

Table 88 Returns to feeding N + P dry season only supplement to a Marginal P herd

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$3,578
Annualised return (profit/year for analysis period)	-$233
Period of analysis (years)	30
Peak deficit (with interest)	-$34,107
Years to peak deficit	15
Payback period (years)	n/a
IRR of "Change" advantage	n/a

5.5.5.1.3 Marginal P herd with Dry season (N +P), Wet season P supplement

The assumptions for the improvement applied in the Dry season (N +P), Wet season P supplemented herd model were the same as the previous responses for supplements fed to breeders in a marginal P herd. That is:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 5% greater conception rates were achieved in the remaining breeders (77%),
- mortality rates fell from 4% to 2% in all breeder classes fed the supplement,
- Cull cows had 10 kilogram heavier live weights at sale (430kg→440kg) and were 10 kilograms heavier in the paddock (450kg→460kg)
- steers and cull heifers achieved the same sale weights with or without the supplement,

Table 89 indicates the Dry season (N +P), Wet season P supplement costs incurred by the marginal P herd. All other treatment costs and prices were identical on per head or per treatment in the "with" and "without" supplement models. The dry season supplement was fed to all breeding cows retained in the herd with the wet season supplement fed to all cows.

Table 89 Dry season and wet season supplement costs for the marginal P deficient herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum
Dry season (N +P) supplement Marginal P cows	$835	150	$11.65
Wet P supplement Marginal P cows	$1309	90	$3.93
Total			$15.58

The feeding of the Dry season (N +P), Wet season P supplement also increased the net costs of feeding without any performance improvement above and beyond the feeding of wet season P only supplements.

Table 90 Returns to feeding N + P dry season plus wet P supplement to a Marginal P herd

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$18,434
Annualised return (profit/year for analysis period)	-$1,199
Period of analysis (years)	30
Peak deficit (with interest)	-$61,210
Years to peak deficit	20
Payback period (years)	n/a
IRR of "Change" advantage	n/c

5.5.5.2 Supplementing breeders in a Deficient P herd

Breeders in a Deficient P herd without supplement had an average weight in the paddock of 435 kilograms, an average sale weight of 410 kilograms and a mortality rate of 6%. Table 91 indicates the reproduction, calf loss and mortality performance of the marginal P breeding herd without a supplement. Conception, mortality and calf loss rates combined to achieve an average weaning rate of 67.24%.

Table 91 Reproduction performance for a Deficient P breeding herd without supplement

	Heifers	First lactation cows	2nd lactation cows	Mature	Aged
Conception rate	80%	80%	60%	75%	70%
Foetal / calf loss	10%	7%	6%	6%	5%
Mortality		8%	8%	8%	8%

5.5.5.2.1 Deficient P herd with P supplement in the wet only

The assumptions for the improvement applied in the Deficient P herd model supplemented only in the wet season with a P supplement were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 6% greater conception rates were achieved in the remaining breeders (67%→73%),
- mortality rates fell from 6% to 4% in all breeder classes fed the supplement,
- 15 kilogram heavier live weights at sale for cull cows and breeders (410kg→425kg) and they were 15 kilograms heavier in the paddock (435kg→450kg),
- steers and heifers achieved the same sale weights with or without the supplement

Table 92 indicates the supplement costs incurred. All other treatment costs and prices were identical on per head or per treatment in the "with" and "without" supplement models. The wet season supplement was fed to all breeders whether they are retained or sold.

Table 92 Supplement costs for Wet season P supplement in the Deficient P herd

Class of supplement	Cost $ /ton landed	Intake grams /head /day	Number of days fed	Cost $/head /annum
Wet season P only Deficient P cows	$1309	60	150	$11.78

Table 93 indicates the impact on returns of supplementing cows over the wet season in a deficient P herd with wet season P only.

Table 93 Marginal returns of supplementing a Deficient P breeding herd wet season P only

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$96,874
Annualised return (profit/year for analysis period)	$6,302
Period of analysis (years)	30
Peak deficit (with interest)	-$26,907
Years to peak deficit	3
Payback period (years)	3
IRR of "Change" advantage	51.6%

5.5.5.2.2 Deficient P herd with Dry season N +P supplement

The assumptions for the improvement applied in the Dry season N +P supplemented herd model were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 5% greater conception rates were achieved in the remaining breeders (67%→72%),
- mortality rates fell from 6% to 4% in all breeder classes fed the supplement,
- Cull cows had 10 kilogram heavier live weights at sale (410kg→420kg) and were 10 kilograms heavier on average in the paddock (435kg→445kg),
- steers and cull heifers achieved the same sale weights with or without the supplement,

Table 94 indicates the dry season only N +P supplement costs incurred by the Deficient P herd. All other treatment costs and prices were identical on per head or per treatment in the "with" and "without" supplement models. The dry season only supplement was only fed to breeding cows retained in the herd.

Table 94 Dry season only supplement costs for the Deficient P herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum
Dry season (N +P) supplement Marginal P cows	$888	150	$20.65

The feeding of the N +P dry season only supplement increases the net costs of feeding compared to the feeding of wet season only P supplements with all performance parameters lower than those achieved by just feeding a P supplement over the summer.

Table 95 Returns to feeding dry season N +P to a Deficient P herd

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$56,247
Annualised return (profit/year for analysis period)	$3,659
Period of analysis (years)	30
Peak deficit (with interest)	-$37,094
Years to peak deficit	3
Payback period (years)	4
IRR of "Change" advantage	24.96%

5.5.5.2.3 Deficient P herd with Dry season (N +P), Wet season P supplement

The assumptions for the improvement applied in the Deficient P herd model supplemented both wet and dry seasons were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 8% greater conception rates were achieved in the remaining breeders (67%→75%)
- mortality rates fell from 6% to 3% in all breeder classes fed both supplements
- 20 kilogram heavier live weights at sale for cull cows (410kg→430kg), 20 kilograms heavier in the paddock (435kg→455kg)
- steers and heifers achieved the same sale weights with or without the supplement

Table 96 indicates the supplement costs incurred. All other treatment costs and prices were identical on per head or per treatment in the "with" and "without" supplement models. The wet season supplement was fed to all breeding cows and the dry season supplement was fed to cows remaining after culling.

Table 96 Supplement costs for the Deficient P herd fed wet season P and dry season N +P

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum	Total cost
Wet season Deficient P cows	$1,309	150	$11.78	
Dry season Deficient P cows	$932	120	$16.52	$28.30

Table 97 indicates the impact on returns of supplementing cows over the wet and dry seasons in a deficient P herd.

Table 97 Returns to feeding Dry season (N +P), Wet season P supplement to a Deficient P herd

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$36,655
Annualised return (profit/year for analysis period)	$2,384
Period of analysis (years)	30
Peak deficit (with interest)	-$57,965
Years to peak deficit	3
Payback period (years)	14
IRR of "Change" advantage	13.38%

5.5.5.3 Supplementing breeders in an Acute P herd

Breeders in an Acute P herd without supplement had an average weight in the paddock of 428 kilograms, an average sale weight of 400 kilograms and a mortality rate of 9%. Table 98 indicates the reproduction, calf loss and mortality performance of the Acute P breeding herd without a supplement. Conception, mortality and calf loss rates combined to achieve an average weaning rate of 57.04%.

Table 98 Reproduction performance for an Acute P breeding herd without supplement

Parameter	Heifers	First lactation cows	2nd lactation cows	Mature	Aged
Conception rate	80%	45%	60%	60%	55%
Foetal / calf loss	10%	7%	6%	6%	5%
Mortality		4%	12%	12%	12%

5.5.5.3.1 Acute P herd with P supplement in the wet only

The assumptions for the improvement applied in the Acute P herd model supplemented over the dry season were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 15% greater conception rates were achieved in the remaining breeders (57%→72%)
- mortality rates fell from 9% to 5% in all breeder classes fed the supplement
- 18 kilogram heavier live weights at sale for cull cows (400kg→418kg), 17 kilograms heavier in the paddock (428kg→445kg)
- steers and heifers achieved the same sale weights with or without the supplement

Table 99 indicates the supplement costs incurred. All other treatment costs and prices were identical on per head or per treatment in the “with” and “without” supplement models. The wet season supplement was fed to all cows whether culled or retained.

Table 99 Supplement costs for the Acute P herd – wet season P only

Class of supplement	Cost	Intake	Number	Cost

	$ /ton landed	grams /head /day	of days fed	$/head /annum
Dry season Acute P cows	$1309	81	150	$15.90

Table 100 indicates the impact on returns of supplementing cows in an Acute P herd – wet season only.

Table 100 Marginal returns of supplementing an Acute P breeding herd – wet season P only

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$695,035
Annualised return (profit/year for analysis period)	$45,213
Period of analysis (years)	30
Peak deficit (with interest)	-$38,877
Years to peak deficit	3
Payback period (years)	3
IRR of "Change" advantage	81.83%

5.5.5.3.2 Acute P herd with Dry season N +P supplement

The assumptions for the improvement applied in the Dry season N +P supplemented herd model were:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 10% greater conception rates were achieved in the remaining breeders (57%→67%),
- mortality rates fell from 9% to 5 % in all breeder classes fed the supplement,
- Cull cows had 12 kilogram heavier live weights at sale (400kg→412kg) and were 8 kilograms heavier on average in the paddock (428kg→435kg),
- steers and cull heifers achieved the same sale weights with or without the supplement,

Table 101 indicates the dry season only N +P supplement costs incurred by the Acute P herd. All other treatment costs and prices were identical on per head or per treatment in the “with” and “without” supplement models. The dry season only supplement was fed to breeding cows retained in the herd.

Table 101 Dry season only supplement costs for the Acute P deficient herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum
Dry season (N +P) supplement Marginal P cows	$932	180	$26.00

The feeding of the N +P dry season only supplement increased the net costs of feeding without any performance improvement above and beyond the feeding of wet season only P supplements. This was even though the cull breeders did not receive the supplement.

Table 102 Returns to feeding N + P dry season only supplement to an Acute P herd

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$435,778
Annualised return (profit/year for analysis period)	$28,348
Period of analysis (years)	30
Peak deficit (with interest)	-$56,453
Years to peak deficit	3
Payback period (years)	4
IRR of "Change" advantage	48.70%

5.5.5.3.3 Supplementing an Acute P herd with dry season N &P and wet season P

The assumptions for the improvement applied in the Acute P herd model supplemented over both the wet and dry season are:

- Conception rates in the maiden heifers were unchanged as they ran on buffel to first mating,
- 16% greater conception rates were achieved in the remaining breeders (57%→73%)
- mortality rates fell from 9% to 3% in all breeder classes fed the supplement
- 25 kilogram heavier live weights at sale for cull cows (400kg→425kg), 22 kilograms heavier in the paddock (428kg→450kg)
- steers and heifers achieved the same sale weights with or without the supplement

Table 103 indicates the supplement costs incurred. All other treatment costs and prices were identical on per head or per treatment in the "with" and "without" supplement models. The wet season supplement was fed to all breeding cows and the dry season supplement was fed to cows kept after culling.

Table 103 P supplement costs for the Acute P herd

Class of supplement	Cost $ /ton landed	Number of days fed	Cost $/head /annum	Total cost
Dry season (N +P) supplement	$932	150	$21.67	
Wet P supplement	$1309	150	$15.90	$37.57

Table 104 indicates the impact on returns of supplementing cows in an Acute P herd both seasons. The benefits, although substantial, appear likely to be lower than benefits available if an appropriate supplementation program was implemented in the wet season alone.

Table 104 Marginal returns of supplementing an Acute P breeding herd – both seasons

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$630,094
Annualised return (profit/year for analysis period)	$40,989
Period of analysis (years)	30
Peak deficit (with interest)	-$87,535
Years to peak deficit	3
Payback period (years)	4
IRR of "Change" advantage	46.98%

5.5.5.4 Summary and discussion of P supplementation strategies

Table 105 summarises the results for the analysis of P supplementation strategies in the Fitzroy region. Feeding P supplements on Marginal P country was only profitable where wet season P alone was fed and a significant reduction in mortality rates combined with a healthy lift in the weaning rate was achieved. Incurring significant costs in distributing P supplements fed in the dry season alone or fed both in the wet and the dry to Deficient P breeders appears unlikely to generate measureable economic benefits. Feeding P to Deficient P breeders in the wet season alone may provide benefits, depending upon the effectiveness to the supplementation program and the costs of distributing the supplements in the wet.

Breeders exhibiting the levels of performance resulting from having an Acute P status show significant gains in performance and sound levels of economic improvement when fed an effective P supplement in the wet season alone or both wet and dry seasons. Feeding P in the dry season alone to an Acute P herd is expected to be significantly less efficient than wet season P feeding and it appears the effort has to be made to get wet season P feeding right.

Table 105 Profitability and financial risk of implementing phosphorus (P) supplementation strategies

Strategy	Annualised NPV[A]	Peak deficit (with interest)[B]	Years to peak deficit	Payback period (years)[C]
Marginal P breeders, wet season P	$5,603	-$7,187	3	3
Marginal P breeders, dry season N+P	-$233	-$34,107	n/c[D]	n/c
Marginal P breeders, dry season N+P, wet season P	-$1,199	-$61,210	n/c	n/c
Deficient P breeders, wet season P	$6,302	-$26,907	3	3
Deficient P breeders, dry season N+P	$3,659	-$37,094	3	4
Deficient P breeders, dry season N+P, wet season P	$2,384	-$57,965	3	14
Acute P breeders, wet season P	$45,213	-$38,877	3	3
Acute P breeders, dry season N+P	$28,348	-$56,453	3	4
Acute P breeders, dry season N+P, wet season P	$40,989	-$87,535	3	4

[A]The annualised NPV represents the average annual change in NPV over 30 years, resulting from the P supplementation strategy and can be considered as an approximation of the change in profit per year.
[B]Peak deficit is the maximum difference in cash flow between the P supplementation strategy and the base scenario over the 30-year period of the analysis. It is a measure of riskiness.
[C]Payback period is 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.
[D]n/c – not calculable

A related study for the Katherine region (reported later in this document) indicated that the large estimated decrease in mortality in acutely P deficient herds due to P supplementation was a key driver of the improved profitability. Separately removing the impact of the changes in growth, fertility and mortality rate from the Katherine region herd model that looked on at herds with an Acute P status, indicated that:

- removing the impact on growth rates alone reduced the herd gross margin by 16%,
- removing the fertility improvement alone reduced the herd gross margin by 22% and
- removing the impact on mortality rates alone reduced the herd gross margin by 26%

In situations where the mortality / morbidity rate of unsupplemented breeders is as high as that implied by Schatz and McCosker (2018), the impact of P supplementation to reduce mortality on the economic performance of the herd would be substantially greater than that estimated in our study.

In the Fitzroy analysis, the steers and heifers were weaned onto buffel grass pastures and sold at the same liveweight regardless of the P status of the breeder herd. This caused all of the economic and financial benefits to be due to reduced mortality rates in the breeder herd, increased weaning percentages and increased sale live weights of cull cows. The optimal cow cull age was also not affected by P supplementation in the Fitzroy analysis; this was in accord with the conclusion of McGowan et al. (2014) that there was no discernible decrease in breeder performance with age in the relatively benign environment of this region.

Our results support best-practice industry recommendations (e.g. as per Jackson et al. 2012) to undertake rigorous analysis of the P status of the beef herd prior to undertaking any supplementation program. Where no significant biological response to P supplementation is expected, there will also be no economic response to provision of additional P. Breeder herds in the Fitzroy NRM region of central Qld performing at the median level indicated in regional surveys (McGowan et al. 2014) are likely to have Adequate P status and hence are unlikely to show an economic response to P supplementation. However, Acute P status breeder herds in the Fitzroy are likely to show a strong economic response to appropriate levels of P supplementation.

A finding that it is highly profitable to provide P supplements across a range of circumstances in northern Australia is not new (Holmes 1990; Jackson 2012). Our analysis therefore appears unlikely, in isolation, to change the paradox identified by Dixon et al. (2011) that currently only a small proportion of cattle grazing P deficient pastures are supplemented or otherwise manage to alleviate P deficiency.

Schatz and McCosker (2018) identify that a contributing factor to low adoption rates is likely to be the lack of published studies showing significant increases in pregnancy percentages from feeding P supplements in northern Australia. We would add that no known research has previously identified the critical importance of the reduction in mortality and morbidity rates associated with appropriate P supplementation of Acutely P deficient herds. Even so, these findings also appear unlikely to improve adoption outcomes if they are progressed in isolation.

The message is that looking at components of herd management in isolation (such a P supplementation) may not reveal a true picture of the nature of the problem. Gaining adoption of P supplementation is likely to require a ‘whole of property management’ approach to be effective, an assertion also made by Foran et al. (1990) and Henderson et al. (2012). The components required to make a P supplementation program effective on an extensive cattle station in northern Australia have complex interactions and may require a complete rethinking of the current herd management strategy and property operations. Furthermore, the potential benefits of P supplementation should ideally be examined on a property by property basis to account for the property-specific details in terms of location, operational scale, land capability, climate, herd performance and existing management practices.

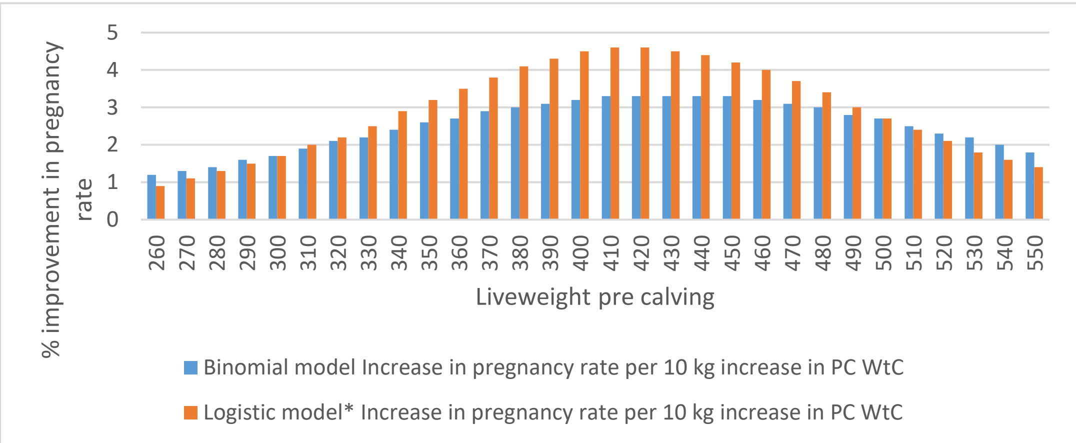
5.5.6 Feeding first calf heifers energy and protein supplements

Energy and protein supplements for first calf heifers are often recommended as best management practice to increase re-conception rates (Dixon 1998; DAF 2018). In this scenario, a change in the re-conception rate of first calf heifers was sought by improving their bodyweight prior to calving. The base herd model identifies that only 78% of first lactation heifers are likely to conceive in the 3-4 year age group compared to 89% and 86% for mature and aged cows respectively.

The parameters of this scenario were based on a study undertaken by Schatz (2010). That study investigated whether pre-partum supplementation during the dry season with a suitable supplement could reliably increase re-conception rates in first-lactation heifers in the Victoria River District (VRD) of the NT. Schatz (2010) concluded that feeding pre-partum protein supplements for a period of at least 100 days until green grass is available at the start of the wet season is a reliable method of changing re-conception rates in first-lactation heifers in the VRD.

Although the trial groups averaged a 42% improvement in conception rates, analysis of the trial data identified that the predicted pregnancy rate will change by between 4% and 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 kilograms. (Figure 16)

Figure 16 Predicted pregnancy rates at different pre calving weights (corrected for stage of pregnancy) and the predicted increase in pregnancy rate for each 10kg increase in PC WtC (Schatz 2010)



*The predictions of pregnancy rate using the logistic model are likely to be more accurate than the predictions from the binomial model (Schatz 2010).

The growth model for the Fitzroy region base herd identifies that first calf heifers are likely to average about 550 kilograms liveweight just prior to calving. The analysis of trial results identifies that feeding these heifers so they are 20 kilograms heavier in bodyweight at the same time should lift their subsequent conception rates from 78% to 80%. (See Table 8 page 41 of Schatz 2010).

The new conception rate was applied to the Fitzroy herd base model to identify the investment returns that may be gained by feeding first lactation heifers with a suitable supplement in this herd with the predicted growth model for heifers. 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 maintain the same grazing pressure and culling strategy.

The existing conception rates for heifers and age groups older than the 3-4 year age group were maintained at the same level. Feeding the protein supplement 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 changes from 77.6% to 77.96%. The breeder herd with the heifer feeding strategy produced about three more weaners per annum on average and total female sales increased by two per annum due to the improved efficiency of the breeding

The calculation of the expected feeding cost per head is shown in Table 106.

Table 106 Feeding costs for PTIC 2-3 year age group heifers

Feeding cost calculator				
Number of PTIC heifers to be fed			110	
Average body weight			550	kg
Food consumed	0.40%		2.2	kg per head per day
Number of days to be fed			100	
Total intake of supplement			220	kg per head
Cost of supplement			$280	per ton landed
Total supplement fed			24	Tons
Total cost of supplement			$6,776	total supplement cost
Cost of feeding out				
Fed out	2	times a week	28.57	times fed
Wages and fuel for 1 feeding out	$50			
Total cost of feeding the supplement			$1,429	
Total cost of the supplement and the feeding out			**$8,205**	
Cost per head fed			$74.59	

Capital expenditure of $5,000 was required for troughs and feeding out equipment.

Table 107 shows the predicted investment returns for feeding protein supplement to first lactation heifers. It appears that the investment will reduce the average annual profit of the enterprise by about $10,000 per annum. This demonstrates that although maintaining body weight is critical to the performance of young breeders, the extra costs associated with achieving extra weaners through supplementing first calf heifers will not be repaid.

Table 107 Marginal returns to feeding energy to first calf heifers

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	-$148,860
Annualised return (profit/year for analysis period)	-$9,684
Period of analysis (years)	30
Peak deficit (with interest)	-$416,285
Years to peak deficit	never
Payback period (years)	never
IRR of "Change" advantage	n/a

5.5.7 Pestivirus management

Bovine pestivirus, taxonomically known as bovine viral diarrhoea virus (BVDV), is ubiquitous in cattle populations around the world. (Kirkland et al 2002) BVDV is believed to be spread almost exclusively by Persistently Infected (PI) animals. PI's were infected with BVDV in utero between approximately months one and four of their pregnancy. They go on to be born persistently infected with BVDV, as their immune system fails to recognise the virus as a pathogen and never mounts a defence against it. Because the virus is allowed to replicate, unchecked, PI's go on to shed extreme amounts of virus for their entire lives. The only way to become a PI is to be born one.

McGowan et al. (2014) reported that 15-21%, 39-50% and 35-40% of north Australian cow herds had prevalence of cows sero-positive to BVDV of <20%, 20-80% and >80%, respectively; recent infection was found in 4-16% of cow herds. St George et al. (1967) had previously reported that 61% of Australian cattle were seropositive and 79% of herds infected, indicating little change in prevalence in 45 years. Both Kirkland et al. (2012) and Morton et al. (2013) also reported a low proportion of cattle herds having recent BVDV infection. Both groups reported that half the herds they studied had 0-30% sero-positive animals, indicating high susceptibility to the virus. The timing and impact of a pestivirus infection on any herd is difficult to predict.

The ability of PI's to continually shed the virus at massive levels for their entire lives has proven to be an exceptionally successful course for viral continuance proven by the fact that over 70% of Australian beef herds are actively infected with BVDV.

Research in northern Australia reveals that in adult cattle, infection with Bovine Pestivirus usually only leads to mild flu-like symptoms with low mortality rates. Once recovered, infected animals develop a long lasting immunity to the disease. (Barkly Beef Newsletter 2014)

Issues occur when heifers and cows are infected for the first time during pregnancy. The effects of the disease vary according to the stage of pregnancy the cow/heifer is in when it becomes infected.

- Infection at the time of mating - disrupts cycling and causes early foetal death
- Infection at 1-4 months - causes abortion or produces PI calves.
- Infection at 4-6 months - causes abortions or abnormal calves (brain and eye defects)
- Infection at 7-9 months - generally causes no problems

Once a heifer or cow has been exposed to the virus and developed immunity, future pregnancies will not be affected even if she is re-exposed to the virus later on. On a limited survey carried out on thirteen properties in the NT, it was found that 63% of animals had been infected with BVDV by the time they were 3 years old. In some areas, around Alice Springs and the Stuart Plateau, it was found that 90% or more of the heifers had been infected with the virus before they were 2 years of age and thus vaccination against BVDV would be unnecessary in these mobs. (Schatz, Melville and Davis 2008) In herds with high numbers of non-immune animals, the introduction of Bovine Pestivirus can result in massive losses through abortion storms, where a high proportion of breeding cows will abort their pregnancies.

What can you do about Bovine Pestivirus?

1. Do nothing and accept current losses or the risk of an abortion storm
2. Vaccinate all heifers prior to joining (immunity lasts 12 months). This protects the heifers during their first pregnancy, during which time they should be exposed to the virus and develop their own natural immunity which is lifelong. This should be sufficient for properties with high levels of infection. A course of two vaccinations 4 weeks to 6 months apart is

required. Immunity does not develop until after the second dose is administered. The second dose must occur 4 weeks prior to joining begins and the current cost of vaccination is approximately $5 per dose and can be purchased ‘over the counter’.

3. Vaccinate heifers as above and continue to administer annual vaccination to the entire breeding herd. This may be necessary for properties with low levels of underlying infection where heifers may not be exposed to the virus naturally and develop their own immunity during their first pregnancy. Provides ongoing insurance against an abortion storm.

4. Autovaccination program using PI animals: This requires the identification of PI animals through blood or ear notch testing and then locking heifers with PI animals at a rate of 3-4% in close contact for 24-48 hours.

5.5.7.1 The impact on returns of vaccinating for pestivirus in a high prevalence herd

This section identifies the parameters of alternative investments to implement the strategies listed above. The analysis firstly considers investments to prevent the potential losses associated with an existing prevalent pestivirus infection in a breeding herd (management options 2 and 3 above) then the expected value of protecting a naïve herd that is at risk of pestivirus infection is considered.

GHD (2015) report the results of modelling that uses an understanding of BVDV epidemiology in Australia and the known incidence of persistently-infected (PI) animals to suggest that, depending on the relative prevalence of BVDV strains with varying abortigenic effect, weaning rate is conservatively estimated to be lower by between 1% and 4.5% as a result of between 3% and 7% of cows being infected in early pregnancy each year.

The first scenario considered here (option 3 above) applied a base herd that has a high prevalence of the disease. This was developed by reducing the conception rates of the original base herd by a uniform 2% for each class of females mated, the same impact as applied by GHD (2015) for high prevalence herds.

The long term benefit of a vaccination program that treated all breeding females each year was set at a 2% per annum improvement in the herd pregnancy rate – the reversal of the disease impact. The vaccine was applied to all breeding age females in the first year of the analysis with the conception rates improving from the second year.

The cost of the vaccine was $4.75 per dose with two doses being applied to heifers entering the breeding herd and all cows retained in the breeding herd receiving an annual booster. Although the vaccination program can often be incorporated in the normal mustering activities, the cost of the vaccine per head was increased to $5 per dose applied to allow for additional labour and time required to apply the vaccine. In this scenario, the vaccination program was continued for the entire 30-year investment period to prevent reinfection of the herd with pestivirus.

Table 108 Marginal returns for an investment to reduce the incidence of pestivirus in a high prevalence herd with treatment for all breeding females

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$15,750
Annualised return (profit/year for analysis period)	$1,025
Period of analysis (years)	30
Peak deficit (with interest)	-$21,219
Years to peak deficit	7
Payback period (years)	15
IRR of "Change" advantage	9.22%

The beef enterprise was slightly better off with a long term vaccination program that treated all breeding females although it does take 15 years for the investment in the vaccine to be repaid. The assumptions require a changeover from the performance of a herd with a high prevalence of pestivirus to a new level of reproduction efficiency. This caused more heifers and cows to be retained as proportionally more became pregnant and led to the peak deficit occurring seven years after the vaccination program commenced. Herds that had a lower impact of the disease than a 2% reduction in the conception rate, on average, would appear unlikely to gain a benefit from an ongoing vaccination program.

It has been suggested that a high level of protection may be gained in a high prevalence herd by treating just the heifers prior to their entry into the breeding herd (Option 2 above). The long term benefit of this vaccination program was assessed by adjusting the costs of treatment for the previous model so that only the heifers were treated. The level of benefits achieved (a 2% per annum improvement in the average weaning rate) was maintained.

Table 109 Marginal returns for an investment to reduce the incidence of pestivirus in a high prevalence herd with treatment for only the heifers

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$56,614
Annualised return (profit/year for analysis period)	$3,683
Period of analysis (years)	30
Peak deficit (with interest)	-$3,276
Years to peak deficit	6
Payback period (years)	6
IRR of "Change" advantage	n/c*

*Not calculable

If a herd with a high prevalence could eliminate losses due to BVDV by vaccinating just the heifers, the benefits of the vaccination program are likely to more than double the option of vaccinating the entire breeding herd on an annual basis. The beef enterprise was better off with a long term vaccination program that treated just the replacement heifers and it now takes six years for the investment in the vaccine to be repaid.

Herds with a high prevalence of the disease that do not show an immediate reduction in the impact of the disease in the remainder of the herd when just the heifers are vaccinated are likely to show benefits of a vaccination program somewhere between options 2 and 3.

5.5.7.2 The impact on returns of vaccinating for pestivirus in a naive herd

This analysis considers the potential impact of pestivirus on a naive herd. A herd that does not have the virus would be at risk of it rapidly spreading through susceptible cattle. The impact of any disease outbreak depends upon the frequency of the infection, the level of impact and the proportion of the herd impacted. Estimates of potential loss associated with a rapid infection of pestivirus have been placed at a 10% to 50% reduction in the herd weaning rate in the year of occurrence (M Sullivan pers. comm.) with an expectation that it would be many years before a similar crash could be expected to reoccur. We assumed a 30% reduction in the herd weaning rate in the year of rapid spread of the virus due to the relatively short mating period applied in this management system. This is probably a worst case scenario as introducing the disease at any time outside the high risk period during and just after mating appears unlikely to cause this level of losses.

Following the method outlined by Malcolm (2003) and McInerney (1996) it is assumed that the cost of an outbreak of the disease could happen with a given probability each year and the occurrence in one year is independent of its occurrence in any other year. That is, the problem is a ‘one-off’ event with an estimated total cost and an associated probability of occurring sometime in a defined planning horizon. It is also assumed that when the loss occurs, it is very unlikely that the impact of the one off event would reoccur within the planning horizon or that practices would be put in place to ensure that it does not happen again. In other words, the costs due to this cause can happen once and once only in the planning period – the probability of re-occurrence is zero (or some very small probability). Our planning period is 30 years.

This type of situation appears to create a problem for benefit-cost analysis because the year in which the benefits and costs occur is unknown, which makes it difficult to obtain an expected present value by discounting the future loss. Applying the discount factor to the probability component of the formula for the expected present value rather than the benefit and cost components can overcome this difficulty. (Read Sturgess and Associates (1992))

The impact of a one off 30% reduction in weaning rate on the number of weaners produced is shown in table 110 for a herd targeting feed on steers.

Table 110 Calves weaned in a naïve herd with and without a one off impact of pestivirus

Class of stock	Base herd	Naive herd impacted by pestivirus
Total cows and heifers mated	642	642
Calves weaned	498	349

Reducing the number of weaners produced from 498 to 349 in the base herd model in one year identifies that the expected impact on herd profit is about $102,000 (undiscounted). This total value includes reduced steer sales sometime after the outbreak and the retention of additional heifers to maintain breeder numbers.

In this example the annual probability of the occurrence of the costs associated with a disease outbreak is once in 30 years and that if it occurs in the planning period it will not recur. At a discount rate of 5 per cent, an event with a 1 in 30 year probability is equivalent to a (discounted) probability of it occurring now of 0.4.

This result is achieved by combining the discounting formula (PV= $Cost/ ((1 - discount rate)/100) x the number of years), and the formula for the probability of the random event, the algebra reduces to: 100/ ((number of years x discount rate) +100). For a 30 year period and discount rate of 5%, the solution is 100/ ((30 x5) +100) = 0.4

The net revenue losses from a virus outbreak would be $102,000 in total, regardless of when it occurred within the planning period. With the above assumptions about the discount rate and the probability of occurrence in the absence of the investment in disease reduction, prevention or control, this would mean that the expected present value of costs of the virus causing the level of impact predicted in a naïve herd over the planning period is $40,800.

The alternative for this naïve herd is to vaccinate the entire breeding herd and prevent the impact of the virus suddenly spreading through a naïve herd. The Present Value of costs for this can be estimated by adding the vaccine cost into the analysis for the full breeding herd from the first year and comparing this to a treated herd with the (naïve) base herd without the vaccine cost. In this case the Present Value of the preventative vaccination program for the 30 year investment period is negative $78,246. That is the property would be $78,246 worse off in present value terms if it vaccinated to prevent pestivirus compared to not vaccinating and not getting an outbreak.

As an expected cost avoided is an expected benefit, the expected benefit of the investment is the difference between the expected additional costs associated with the disease outbreak and the additional costs of preventing the disease. A vaccination program in a naïve herd has an expected

Net Present Value of -$37,446. This is the difference between the cost of the vaccination program and the expected value of the disease outbreak.

These results are a bit challenging. It appears that if you have a high prevalence herd you are slightly better off by vaccinating but the benefit is probably not measureable and if you have a naïve herd you are probably better off by not vaccinating. The cost of pestivirus in an extensive breeding herd appears to be the cost of identifying some PI cows and running them with the weaner and yearling heifers post weaning. That is, the likely economic cost of the disease is negligible where managers are alerted to the risks associated with the disease and take appropriate steps to manage those risks.

5.5.7.3 Notes on the impact of discounting on the cost /timing of the outbreak

A key component of the analysis of Pestivirus is the lack of knowledge of the timing of a potential outbreak leading us to conclude that we expect it to happen sometime in the next 30 years. If we knew the timing of the event it would be placed in the discounted cash flow (dcf) budget at the appropriate time with the costs (and benefits) discounted to create a Present Value of the expected impact. For example:

- if the outbreak was expected to occur in year one, the Present Value of the Costs of an outbreak of the virus would be -$84,963,
- if it was expected to occur in the 15th year, the Present Value of the costs would be -$42,912 and
- if the outbreak did not occur within the 30 year investment horizon, the Present Value of the costs of an outbreak would be $0 as it has no impact on sales within the period of the analysis

Extending the analysis past a 30 year investment horizon will not significantly change the results. The impact of a 5% discount rate on the Present Value of benefits or costs occurring after year 30 means that their potential occurrence will probably not significantly impact the strategy considered by a decision maker. It may also be difficult to convince beef producers to take into account risks that may randomly occur sometime well into the future when their production system is notoriously dynamic and risky in the short to medium term. The method of applying a probability weighting to the cost of the outbreak provides a way of comparing alternative courses of action where the timing of events are unknown and they are only likely to occur once in the planning period.

It appears that the manager of a naïve breeder herd may be better off closely managing herd biosecurity and taking the risk of an outbreak. There has to be a good reason why their herd is naïve given that most herds are not. They would need to identify why their herd has that status and then assess whether those factors will continue.

Managers of herds with a high prevalence of the virus probably need to assess the losses occurring due to the virus before they take action. If calf loss is well above expectations and no other likely causes can be identified, then a vaccination program may be worthwhile.

5.6 Other strategies

5.6.1 Organic beef production

Compiled by Holly Reid (DAF Charters Towers)

This scenario investigated the implementation of organic certification and subsequent economic outcomes for a grazing business. Adaptations from the base herd included the following:

- Reduced grazing pressure (20%)
- Removal of the costs of chemical control of cattle tick, and drought feeding
- Adding the one off cost for certification ($3500) and the annual cost of auditing ($1182)
- Changing the prices of steers and heifers from the third year to reflect an estimated organic market price premium of 25%

Reducing the grazing pressure was assumed to remove the requirement for supplementation or drought feeding. The reduction in AEs of 20% has been previously seen as reasonable in other economic analysis undertaken with beef producers converting traditional production to organic production. The reduction in stocking rate was predicted to improve diet quality of cattle and allowed the herd to be fully sufficient on pastures without mineral supplements.

The organic steer prices were based on the JBS Rockhampton organic price grid. Cull cow sale prices were kept the same in both models as organic cow prices have been variable and the ability of the cow herd to achieve organic status in the medium term was unknown.

The overall herd productivity in terms of weaning rates, growth rates, mortality rates, sale weights were not changed. Changing only the variables that are affected by the transition to organic status allowed comparison to the base model.

Table 111 indicates the impact on returns of converting to organic beef.

Table 111 Marginal returns for converting to Organic beef

Factor	Value
Interest rate for NPV	5%
Marginal NPV of "Change" advantage	$37,445
Annualised return (profit/year for analysis period)	$2,436
Period of analysis (years)	30
Peak deficit (with interest)	Na
Payback year	Na
Payback period (years)	Na
IRR of "Change" advantage	-0.28%

The result can be attributed entirely to the capital released by the 20% reduction in grazing pressure (and the associated return of capital) as once this was completed the organic property was less profitable than the base herd operation. That is, the cash released by the herd reduction is what makes this change slightly profitable. Over the longer term, the 25% price premium for steers and heifers does not offset the 20% reduction in grazing pressure. If the whole herd was to become organically certified the result may be more favourable.

5.6.2 Wagyu beef production

The Wagyu is a Japanese beef cattle breed characterised by high marbling and eating quality attributes (AWA 2018). Australia has the highest fullblood Wagyu beef cattle population outside of Japan (Wagyu International 2018). However, Wagyu breeding and feeding in Australia is dominated by crossbreeding, with a small fullblood segment expanding from a tiny base (AWF 2018). The industry is growing rapidly due to historically high price premiums for Wagyu-infused cattle, although estimated to be only 1-2% of the total Australian cattle herd (AWF 2018).

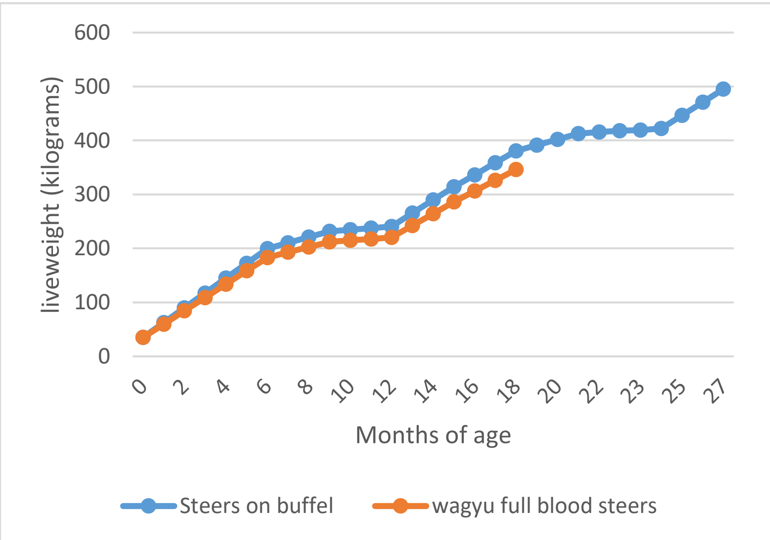
The first cross of a Wagyu fullblood (100% Wagyu genetic content) over another breed is referred to as an F1. Further crossing of Wagyu is referred to as 'breeding up'. A purebred Wagyu is achieved after at least four generations of crossbreeding using Wagyu fullblood sires and has greater than 93% Wagyu genetic content. No amount of crossbreeding can result in a fullblood Wagyu being produced as fullblood animals can only be produced from the mating of a 100% fullblood male Wagyu and a 100% fullblood female Wagyu (AWA 2018).

Most crossbred Wagyu cattle are sold to the feed-on market at ca. 340-400 kg liveweight where they are commonly fed for ca. 450 days. Around 80-90% of Wagyu-infused beef is sold to export markets with the remainder consumed domestically (AWA 2018). As most Wagyu-infused beef is produced for export in relatively long feedlot programs, the segment is historically vulnerable to both feed price and currency fluctuation.

This scenario converts the breeding herd to Wagyu genetics over time by replacing the current bull herd with fullblood Wagyu bulls. No Wagyu females were purchased and the Wagyu content of the breeding herd changed as replacement heifers with Wagyu content are retained. The normal culling strategy was continued and replacement heifers were first mated at 18 to 24 months old. Pure bred Wagyu steers and heifers had growth rates 10% lower than the base herd average growth rates.

The average price of the Wagyu fullblood bulls was set at $7000 per head or about 40% more on average than the base herd replacement price. Purchasing the 22 Wagyu bulls cost $160,000 (included transport costs). The current breeding bull herd was sold for $2500 per bull giving a net cost of replacing the bull breeding herd of $105,000. Purebred Wagyu steers were sold at a younger age and lighter weight than the base herd feed on steers. (Figure 17)

Figure 17 Growth path for Wagyu purebred steers



Additional treatment costs were incurred to maintain the productivity of the purebred Wagyu herd. Tick control costs were increased plus additional supplements and vaccines were required. A DNA test is required at a cost of $50 per weaner.

Table 112 Wagyu full blood treatment costs

Parameter			Females						Steers		
Treatment	Weaner Heifers	Weaner Steers	1-2 yrs Kept	*1-2 yrs Sold*	2-3 yrs Kept	*2-3 yrs Sold*	3 yrs + Kept	*3 yrs + Sold*	1-2 yrs Kept	*1-2 yrs Sold*	Bulls Kept
Weaner feed	$15	$15									
NLIS, station tags	$6.50	$6.50	$0.20	*$0.20*	$0.20	*$0.20*	$0.20	*$0.20*	$0.20	*$0.20*	$0.20
Clostridial vaccines	$3.04	$1.10									
Lepto vaccine			$2.34		$1.17		$1.17				$1.20
Tick control	$9.67	$9.67	$13.75	*$13.75*	$17	*$17*	$17	*$17*	$13.75	*$11.20*	$20
Vibrio vaccine											$10
Drought feeding			$5.00		$6.00		$7.50				$10
Pregnancy testing			$5.00	*$5.00*	$5.00	*$5.00*	$5.00	*$5.00*			
Tick fever vaccine	$4.93	$4.93									
Three day vaccine											$10
Supplements	$8	$8	$10		$10		$10				$10
(DNA test)	$50	$50									
Cost/group	$106.8	$96.54	$41.49	*$18.95*	$44.57	*$22.2*	$46.07	*$22.2*	$13.95	*$11.4*	$66.6

The reproductive efficiency of the Wagyu purebred herd was unchanged and the mortality rates were increased by 25% across all classes of livestock.

Table 113 Breeder herd components for the base herd targeting feed on steers with full purebred Wagyu

Breeder herd components	Base herd	With Wagyu
Total cows and heifers mated	642	794
Calves weaned	498	616
Weaner steers	249	308

Cull heifers attracted a price premium from year 5 of the transition which increased in equal increments to a 100% price premium by year 10. Sale steers achieved a 100% price premium in year 7 of the transition and this was maintained to the end of the investment period. Cull cows did not receive a price premium. Labour costs were increased by $10,000 per annum to cover the additional mustering and handling costs associated with Wagyu cattle in this region.

Table 114 indicates the impact on returns of converting to Wagyu purebred if the expected price premiums reduce from year 10. This has been done as it is difficult to predict significant price premiums being continued into the long term future with any form of beef production. The impact of a reduced price premium was initially tested by incrementally reducing the price premium back to zero from year 10 of the analysis.

Table 114 Marginal returns for converting to purebred Wagyu with the price premium reduced after year 10

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$646,738
Annualised return (profit/year for analysis period)	-$42,071
Period of analysis (years)	30
Peak deficit (with interest)	-$1,927,459
Years to peak deficit	never
Payback period (years)	never
IRR of "Change" advantage	n/a

Table 115 shows the benefit of maintaining the price premiums up until year 20 and then incrementally reducing them to zero. It appears that if the price premiums are maintained up until year 20 of the investment and then reduce down to zero over the following 6 years, the investment in producing full blood Wagyu could be marginally profitable but it must be recognised that the investment is not paid back within the 30 year period.

Table 115 Marginal returns for converting to purebred Wagyu with the price premium reduced after year 20

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$49,471
Annualised return (profit/year for analysis period)	$3,218
Period of analysis (years)	30
Peak deficit (with interest)	-$269,104
Years to peak deficit	4
Payback period (years)	n/a
IRR of "Change" advantage	n/a

Over the longer term, the profitability of the beef system is significantly improved if the price premiums are maintained for the entire investment period.

Table 116 Marginal returns for converting to full blood Wagyu with the price premium maintained for the life of the investment

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$506,411
Annualised return (profit/year for analysis period)	$32,943
Period of analysis (years)	30
Peak deficit (with interest)	-$269,104
Years to peak deficit	4
Payback period (years)	12
IRR of "Change" advantage	13.72%

6 Region 2: The Katherine region

The scenarios modelled in this section are based on the former ABARES Region 713 (ABARES 2012) of the Northern Territory highlighted in green in Figure 18.

Figure 18 Australian broad acre regions applied by ABARES

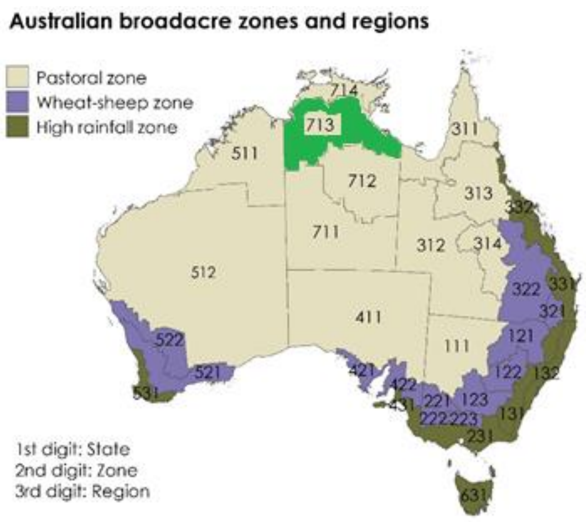


Table 117 indicates about 2.5% of the region has been developed to improved pastures. ABS (2012) indicates the region carries about 1 million head of cattle at an estimated stocking rate of about 17 hectares per head.

Table 117 Area of improved and other pasture, female breeder herd and total meat cattle northern Australia*

Region	Grazing on improved pastures (ha)	Grazing on other land (ha)	Cows and heifers one year and over	Total meat cattle	Stocking rate (grazed ha /head)
713	408,984	16,384,174	552,929	996,388	16.85

*Source: ABS 7121.0 - Agricultural Commodities, Australia, 2010-11 available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02010-11

The region has 114 beef properties that run an average of almost 9,000 head of cattle. (Table 118)

Table 118 Number of properties and average property size in ABARES regions*

Region	Number of properties	Average property size (ha)	Average number of meat cattle
713	114	147,308	8,740

*Source: ABS 7121.0 - Agricultural Commodities, Australia, 2010-11 available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02010-11

6.1 Location and climate

Figure 19 identifies the approximate location of the tropical savannah region of northern Australia.

Figure 19 Tropical savannah bioregion (© CoolAustralia.org)

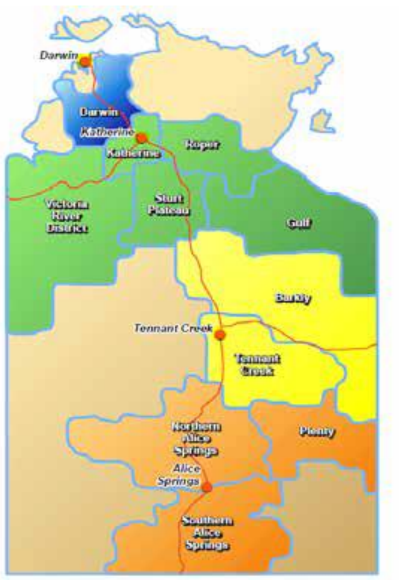
The tropical savannah bioregion is defined by a tropical climate and a landscape made up of small trees and shrubs and grasses covering the ground and makes up 23% of Australia land mass. The Katherine region is found in a more northern part of the tropical savannah bio-region.

6.1.1 The 2010 NT Pastoral Industry Survey

The 2010 NT Pastoral Industry survey (Cowley 2015) captured information from 50% of the Northern Territory pastoral industry.

Figure 20 shows the survey regions. The Katherine survey region (shown in green) corresponds closely with ABS region 713. The NTDPI survey data provides detailed information concerning the husbandry practices and other characteristics of beef cattle properties located in the region.

Figure 20 Map of the Northern Territory showing the survey regions and districts



6.1.2 The Katherine region

The Katherine region is divided into five districts: Katherine/Daly, Roper, Gulf, Victoria River and Sturt Plateau.

- The Katherine/Daly district is typified by large areas of rugged hills and ridges, with the most pastorally important land being made up of red earths with tropical tall grasses.
- The Roper and Gulf districts are typified by soils that are shallow, coarsely textured and stony, and vegetation of open woodland dominated by Eucalyptus.
- The Victoria River district (VRD) can be divided into two land types: rugged and hilly with valleys of tropical tall grass and more undulating country of plains dominated by Mitchell grass.
- The Sturt Plateau is characterised by red and yellow earths with vegetation of Eucalyptus-dominated woodlands, and an understorey of ribbon grass, perennial sorghum and kangaroo grass.

The region has a semi-arid monsoonal climate and experiences two distinct seasons. The wet season occurs from October to April and the dry season from May to September. Rainfall is highly variable from year to year, but there is a distinct gradient of decreasing mean annual rainfall ranging from 1000 mm in the north to 400 mm in the south of the district. Mean daily temperature maximums range from about 27 ºC in July to almost 40 ºC in November.

6.1.3 Survey data for the Katherine region

Table 119 is a summary of data collated by the 2010 Pastoral Industry Survey (Cowley 2015) for the Katherine region. Unless otherwise noted, the values are for the median.

Table 119 Factors and values revealed by Katherine region survey data

Factor	Value
Property size	2232 km^2
Number of paddocks	16
Paddock size	70 km^2
Man-made water points	12
Grazed area per water point	66 km^2 /point
Properties carrying out infrastructure development (2009-2010)	
-water point development	77%
-paddock subdivision	54%
-drafting yards	33%
Expenditure on all infrastructure	$200,000
Average number of cattle	10,730
Percentage of properties increasing numbers since 2004	38%
Main enterprise type – breed and sell mainly for live export	58%
-breed and sell to transfer to rest of Australia	32%
-growing /finishing of transferred cattle	3%
Main markets –Live export	55%
-Abattoirs	10%
-Backgrounders	25%
Percentage of properties that sold heavy cull cows direct to slaughter	41%
Percentage of properties that held heavy cull cows held over	25%
Percentage of cattle turned off May to October	87%
Average mustering costs per head	$13.32
Percentage bulls used	4%
Percentage properties testing bull soundness	13%
Weaning percentage –First joined	78%

-Second joined	46%
-Mature breeders	61%
Estimated calf loss	11%
Average percentage breeders culled annually	12%
Percentage of breeders segregated	46%
Percentage of producers pregnancy testing cows (mainly dry and cull cows)	84%
Percentage of stock tagged for performance recording	23%
Percentage of properties that don't performance record and don't plan to	41%
Percentage of properties control mating maiden heifers	41%
Percentage of properties control mating first calf heifers	24%
Percentage of properties control mating mature breeders	21%
Estimated mortality rates in breeders	4.2%
Percentage of heifers kept as replacements	58%
Percentage of retained heifers mated 18-24 months old	82%
Percentage of heifers 250 to 300 kg at mating	67%
Percentage of properties segregating heifers from breeders	68%
Average minimum weaning weight (first round and second round)	129 kg 97kg
Average weaning weight (first round and second round)	174 kg 140 kg
Percentage of livestock provided with supplements in the dry	59%
Percentage of livestock supplemented in the wet	48%
Percentage of livestock supplemented all year	18%
Cost of dry season supplements ($/head)	$16.36
Cost of wet season supplements ($/head)	$12.67
Percentage of properties using HGP's	56%
Percentage of properties with improved pastures	51%
Percentage of region under improved pasture	3%
Percentage of cattle vaccinated for Botulism	93%
Percentage of bulls vaccinated for Vibriosis	61%
Percentage of weaners vaccinated for Clostridial diseases	21%

Major points in summary:

- The majority of properties in the region are breeder operations turning off stock to the live export trade with stock unsuited to live export sent to slaughter in Queensland. (Or to the abattoir outside of Darwin when it is open)
- Environmental and market conditions require cattle to have a high Bos indicus content
- Live export steers, cull cows and live export heifers are the major turn-off classes for stock.
- Most properties do not control mate their mature cows (79%) but almost 50% segregate them.
- Most properties feed supplements of some form to most classes of breeding stock.
- Most properties use pregnancy testing to at least confirm cull females
- A large proportion of properties identified water points, paddock subdivision and yards as their priority for capital expenditure.
- Improved pastures occur on more than 50% of properties but the percentage of the region sown to improved pastures is between 2.5% to 3%.
- Reproduction efficiency is highest at the first mating and lowest the second mating.
- The majority of heifers (almost 60%) are retained for breeding purposes.

6.2 Representative property details

6.2.1 The property

The hypothetical property is located about 600 kilometres from Darwin and about 300 kilometres from Katherine. It has a total area of 1470 km^2 (147,000 hectares) and carries about 9,000 head of cattle or 7,400 Adult Equivalents. The property has 12 main paddocks that range between 5,000 hectares and 20,000 hectares in size.

6.2.2 Beef production activity

The modelled activity was a self-replacing breeding and growing activity that relied on the production of weaners by a breeding herd. Weaner steers enter a growing system that varied in size with the period of time steers were retained prior to sale. Weaner heifers were used to maintain the breeding herd or are culled and sold. Breeding cows were culled if dry and empty or had significant faults at the first round muster and on age.

Herd bulls were retained in the breeding herd for an average of five years. Cull herd bulls and the majority of cull cows were expected to be sold to the abattoirs. Steers and surplus heifers had a variety of marketing opportunities although the plan was to sell about 80% of the steers between 2-3 years old and the remainder between 3-4 years old to the live export market. Cull heifers were sold after their first mating. About 4% were culled prior to mating with the remainder culled on a negative pregnancy test after mating.

6.2.3 Steer and heifer growth model

Cowley (2012) described the expected pre-weaning growth of male and females weaners for this environment. Table 120 shows the predicted pre-weaning growth rate identified for each month and averaged for each calving period.

Table 120 Pre-weaning ADG (kg/day) used to develop growth models (Cowley 2012)

Month	Male	Average	Female	Average
Jul	0.65		0.62	
Aug	0.65	0.64	0.62	0.61
Sep	0.62		0.59	
Oct	0.6		0.57	
Nov	0.72	0.75	0.62	0.66
Dec	0.92		0.8	
Jan	1.03		0.89	
Feb	0.92	0.93	0.8	0.81
Mar	0.85		0.74	
Apr	0.8		0.7	
May	0.75	0.76	0.67	0.67
Jun	0.72		0.65	

This data was used to underpin the growth model for both steers and heifers. Table 121 shows the expected "average" birthdate and weaning date plus the pre weaning performance of the steers and heifers on the property.

Table 121 Birthdate, weaning and pre weaning performance

Calving period	Calving period 1 JAS 1/07/2016	Calving period 2 OND 1/10/2016	Calving period 3 JFM 1/01/2017	Calving period 4 AMJ 1/04/2017

	30/09/2016	31/12/2016	31/03/2017	29/06/2017
Days of calving period	91	91	89	89
Average calving date	15/08/2016	15/11/2016	14/02/2017	15/05/2017
Average weaning date	17/05/2017	17/05/2017	10/10/2017	10/10/2017
Age at weaning (months)	9.0	6.0	7.8	4.8
Days to weaning	275	183	238	148

There is evidence that growth during the first post-weaning dry season is influenced by weaning weight (Schatz, 2011). Therefore, average daily gains in the first post-weaning dry season were adjusted for weaning weight (Table 122).

Table 122 Adjusted dry season average daily gain (ADG) for the first post weaning dry

Weaning weight range (kg)	Dry season ADG (kg/day)
100-120	-0.022
121-140	-0.038
141-160	-0.054
161-200	-0.070
201-220	-0.086
221-240	-0.102
241-260	-0.118
261-280	-0.134

Cowley (2012) used steer growth data from the Northern Territory Live weight Gain project (MLA Final Report, in publication), the Mount Sanford and Pigeonhole grazing trials (unpublished) and heifer and steer growth data from VRRS (unpublished) to model post weaning growth. Table 123 details the average daily gain used in the modelled herd post weaning.

Table 123 Post-weaning average daily gain (ADG) in kilograms per day used to develop steer and heifer growth models

		Wet 1	Dry 2	Wet 2	Dry 3	Wet 3	Dry 4	Wet 4
Female	Round1 weaners	0.5	0.13	0.45	0.1	0.38	0.1	0.3
	Round 2 weaners	0.47	0.13	0.45	0.1	0.38	0.1	0.3
Males	Round 1 weaners	0.55	0.14	0.5	0.11	0.42	0.11	0.33
	Round 2 weaners	0.52	0.14	0.5	0.11	0.42	0.11	0.33

Table 124 shows the expected “average” birthdate and weaning date plus the pre weaning performance of the steers and heifers on the property as applied in the starting herd model.

Table 124 Birthdate, weaning date and pre weaning performance

Factor	Value	
Average calving date	15/11/2018	
Birth weight	30	kg
Average weaning date	16/05/2019	
Age at weaning	6.0	months
Days to weaning	182	days
Male calf average daily gain birth to weaning	0.8	kilograms / day
Reduction in growth rate compared to steers	5%	
Heifer average daily gain birth to weaning	0.76	kilograms / day

Table 125 indicates the expected post weaning seasonal performance for steers and heifers. Steers were assumed to gain weight at about 0.25 kg/head/day to achieve 90 kg/head/annum post weaning and heifers to gain ca. 0.23 kg/head/day to achieve 86 kg/head /annum post weaning.

Table 125 Expected growth of steers and heifers by season and age

Month	Days	Steers kg/d	Steers kg / head	heifers kg/d	Heifers kg / head
Jan	31	0.6	18.6	0.57	17.7
Feb	28	0.6	16.8	0.57	16.0
Mar	31	0.6	18.6	0.57	17.7
Apr	30	0.55	16.5	0.52	15.7
May	31	0.5	15.5	0.48	14.7
Jun	30	0	0.0	0	0.0
Jul	31	0	0.0	0	0.0
Aug	31	0	0.0	0	0.0
Sep	30	0	0.0	0	0.0
Oct	31	0	0.0	0	0.0
Nov	30	0	0.0	0	0.0
Dec	31	0.13	4.0	0.12	3.8
Total	365	0.25	90.00	0.23	85.5

Figure 21 shows the predicted growth path starting from a common date. This steer (and heifer) growth model underpins the herd growth performance for the regional property scenario.

Figure 21 expected liveweight by months of age for steers

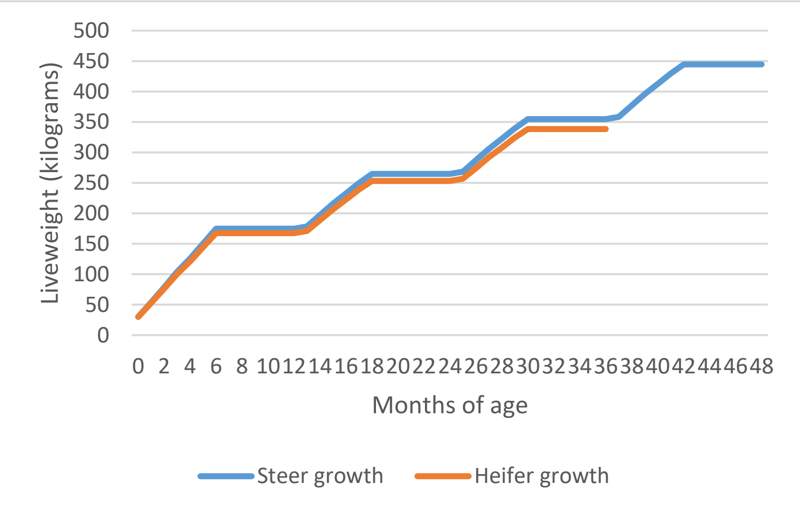


Table 126 shows the predicted sale weights for the steers as calculated in the program Splitsal. The cut off weight was taken to be 320 kilograms in the paddock. At this cut off weight, about 81% were sold at 29 months of age in May with an average weight of 368 kilograms. The remaining 19% were sold in May the following year with an average weight of 388 kilograms in the paddock. May was chosen as a sale weight to fit in with the expected access to transport facilities after the wet season.

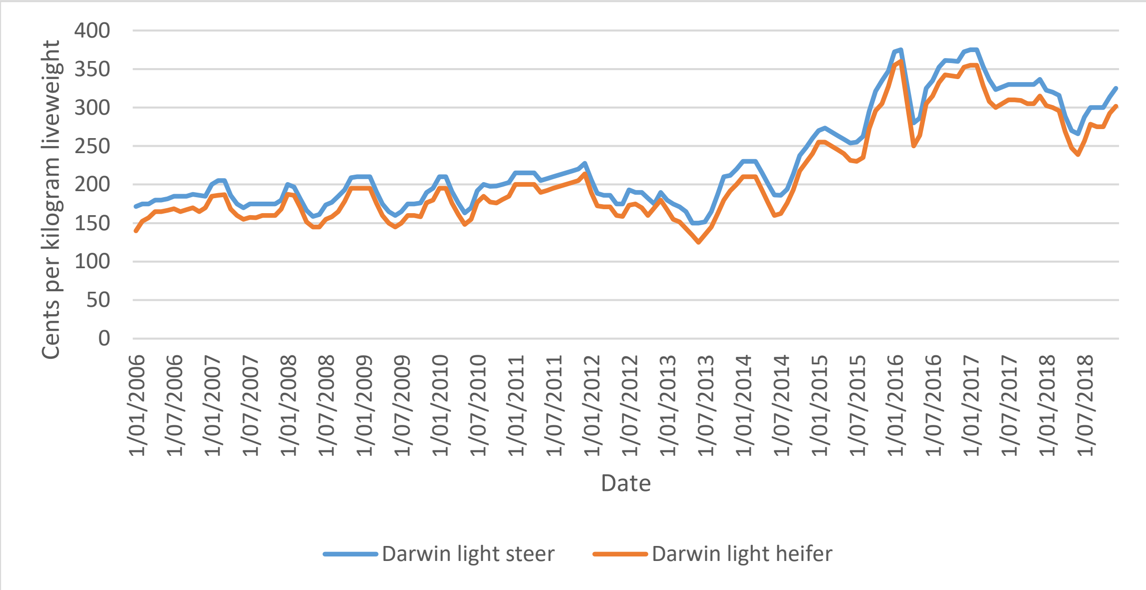
Table 126 Steer sale weights

Average (mean) liveweight of group	355	Cutoff weight for first sale age	320
Standard deviation (SD) of weights	40	% of group above cutoff weight	81%
		Average weight of heavier group	368
In a "normal" distribution, 95% of individual weights will range from 277 kg to 433 kg		Average weight of lighter group	298
		Expected gain if sold at next age	90
		Weight of lighter group by next age	388

6.2.4 Prices

Price data available for Darwin live export markets and North Queensland slaughter markets was relevant to the prices for beef producers in the region. (See MLA market statistics database at http://statistics.mla.com.au/Report/List) Figure 22 shows the prices of live export light steers and light heifers at Darwin from January 2006 to December 2018. Prices for most live export classes of cattle have risen dramatically over recent times.

Figure 22 Live export steer and heifer prices Darwin



The recent volatility in prices makes it very difficult to identify appropriate prices for long term modelling purposes. Heavy export steers and heifers have not been a feature of recent live export markets in Darwin and may or may not be relevant as market options in the future plus the recent opening (and then closing) of the export abattoir in Darwin may change the balance between slaughter cattle and live export cattle but this is also unknown.

In this analysis, the "average of averages" values calculated from 12 year and 5-year average of recent prices were applied to reflect the expected average for prices into the future. The relevant data is highlighted in green in Table 127. Analysts are strongly encouraged to apply prices for each class of cattle that they think are relevant for their purposes.

Table 127 Price* ranges for Darwin live export and North Queensland slaughter markets

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

*All prices were recorded as cents per kilogram liveweight equivalent. NQ slaughter prices were converted at an assumed dressing percentage of 52%.

Table 128 shows the prices, selling costs net price per head for sale stock applied in the base herd model.

Table 128 Prices worksheet showing model selling costs, gross and net prices

Group Description:	Paddock weight Kg/head	Weight loss to sale (%)	Sale weight Kg/head	Price $/kg	Commission % of Value	Other selling $/head	Freight $/head	Gross Price	Total Selling & Freight
Heifer weaners	172	5%	163	$2.00	3.00%	$25.00	$29.25	$326.80	$64.05
Heifers 1 year	255	5%	242	$2.10	3.00%	$30.00	$30.79	$508.73	$76.05
Heifers 2 years	339	5%	322	$2.40	3.00%	$40.00	$36.56	$772.92	$99.75
Cows 3 years	410	5%	390	$1.70	0.00%	$5.00	$41.79	$662.15	$46.79
Steer weaners	172	5%	163	$2.60	3.00%	$25.00	$29.25	$424.84	$67.00
Steers 1 year	267	5%	254	$2.50	3.00%	$40.00	$30.79	$634.13	$89.81
Steers 2 years	368	5%	350	$2.60	3.00%	$40.00	$39.00	$908.96	$106.27
Steers 3 years	388	5%	369	$2.60	3.00%	$40.00	$40.34	$958.36	$109.09
Cull bulls	650	5%	618	$2.00	0.00%	$5.00	$65.00	$1,235.00	$70.00

An allowance for 5% weight loss was made between the paddock weights identified in AECalc to the sale weights identified in the Prices worksheet. The expected selling costs of each class of stock varied due to whether they were sold at live export prices or at slaughter prices. Table 129 shows the expected transport costs per head for each potential class of sale cattle.

Table 129 Transport cost calculations

	Weaners	Heifers 12-24 m	Heifers 24-36 m	Cows	Steers 24-36 m	Steers 36-42m	Bulls
Transport cost ($/deck/km)	$1.95	$1.95	$1.95	$1.95	$1.95	$1.95	$1.95
Distance (km)	600	600	600	600	600	600	600
Number of head per deck	40	38	32	28	30	29	18
Freight cost/head	$29.25	$30.79	$36.56	$41.79	$39.00	$40.34	$65

6.2.5 Husbandry costs and treatments

Table 130 and 131 show the treatments applied to the various classes of cattle in the model.

Table 130 Treatments applied and cost per head

	Weaners	Females 1-2 years	Females 2-3 years	Females 3 years +	Steers	Bulls
Botulism C&D	$1.80	$0.90	$0.90	$0.90	$0.90	$0.90
Weaner feed	$3.75					
NLIS tag	$3.00					
Dry season supplement	$8.74	$18.20	$28.21	$28.21	$18.20	$28.21
Vibrio vaccine bulls						$10
Pregnancy testing		$2.50	$2.50	$2.50		

The breeder herd and steers receive supplement dry lick in the dry season.

Table 131 Treatment total cost per head

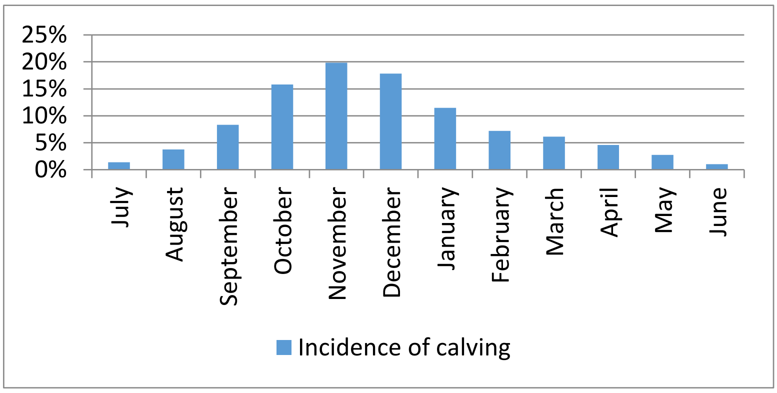
Husbandry costs/head (variable costs only)	$/Heifer Wnr to 1 yr.	or cow 1-2yrs	aged: 2-3yrs	3yrs +	$/Steer Wnr to 1 yr.	or bullock 1-2yrs	aged: 2-3yrs	$/Bull All ages
Total cost/hd on keepers	$17.29	$19.10	$31.61	$29.11	$25.29	$19.10	$19.10	$39.11
Total cost/hd on sale cattle	$8.55	$2.50	$2.50	$2.50	$8.55	$0	$0	$0

6.2.6 Other herd performance parameters

6.2.6.1 Distribution of calving

Bull control in the region is often difficult due to large paddock size, multiple water points and sometimes rugged terrain. Hence, uncontrolled (or continuous) mating is practiced by the large majority of properties in this region (Cowley 2015). Calving is largely dictated by rainfall, with the peak of conceptions occurring several months after the first significant rainfall (Bortolussi et al. 2005). However, calving does occur at other times of the year. Figure 23 shows the distribution of calving in a breeder herd with continuous mating for the period 1995 to 2001 at Victoria River Research Station (VRRS).

Figure 23 Calving distribution in a continuous mated trial herd at VRRS 1995-2001



The trial data from the VRRS (Cobiac 2006) identifies that 85% of calf births occurred from October to March with 15% occurring from April to September.

6.2.6.2 Calving seasons

The incidence of calving shown in Figure 23 was organised into calving seasons to allow modelling of the impact of the season of calving and associated weaning activities on herd productivity. Four calving seasons were applied:

- Jul - Sep (Late Dry)
- Oct – Dec (Early Wet)
- Jan – Mar (Late Wet)
- Apr – Jun (Early Dry)

These four calving periods were chosen to best fit the expected 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 24 compares the percentage of calves born in each season for:

- Herds with continuous mating in the Northern Forest country type (Cash Cow database 2014 - Kieren McCosker NTDPIF personal communication)
- All trial genotypes in the VRRS data (Cobiac 2006)
- Only the Droughtmaster cows in the VRRS data. 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 24 Incidence of calves by calving season

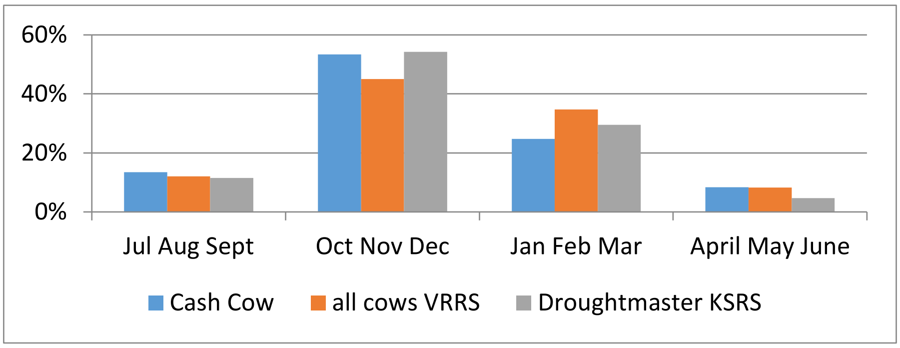


Table 132 shows the percentage of calves expected to be born in each calving season when the Cash Cow and the more representative data for the VRRS Droughtmaster cows were averaged.

Table 132 Percentage of calves born in each calving season

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

The average number of calves born in each season is expected to be 12% in the late dry season (Jul Aug Sept), 54% in the early wet season (Oct Nov Dec), 27% in the late wet season (Jan Feb March) and 7% in the early dry season (April May June). The inter-calving period of individual breeders will cause individual cows to drift between the periods but, on average, we expect about 80% of calves to be born in the early and late wet period.

6.2.6.3 Calf loss

Rates of calf loss from confirmed pregnancy to weaning in Brahman herds in northern Australia range from 14% (Brown, 1998) to 31% (Fordyce et al., 1990). The average calf loss across the Northern Forest country type in the Cash Cow project was 15% (McGowan et al 2014) with a significant effect of calving period also found. Calf loss peaked between July-September (20%) presumably due to increased mustering activity and hence increased likelihood of mismothering to a low of 9% between Dec-Jan. Calf loss was also influenced by region, dam age, being exposed to hot weather during calving and previous success raising a calf. Calf loss in the VRRS herd with continuous mating was 13.5% on average. (Cobiac 2006)

6.2.6.4 Female and breeder mortality

A comprehensive study of breeder mortality in northern Australia found an average breeder mortality rate of 8% (Henderson et al 2012). They distinguished between female and breeder mortality but had trouble accurately separating breeder mortality from overall estimates of female mortality as they could not clearly distinguish between breeding and non-breeding females in the data collected.

Their estimates for total female mortality for the Gulf, Sturt Plateau and Katherine regions combined averaged 5.86% and 6.09% for the Victoria River District. On this basis, female mortality averaged about 6% across the combined regions that make up the Katherine region. Average breeder mortality for the Victoria River District was calculated at 8.58% and 11.3% for the Gulf, Sturt Plateau and Katherine regions combined. On this basis, breeder mortality averaged 10% across the combined regions that make up the Katherine region.

The mortality rate in the VRRS trial herd averaged 2.1% between 1995 and 2001. (Cobiac 2006) It is apparent from the data that higher levels of inputs and management of breeding stock can significantly reduce the average rate of mortality.

6.2.6.5 Reproduction efficiency

Table 133 records the median values for pregnant within four months of calving (P4M), annual pregnancy rate, foetal /calf loss and "contributed a weaner" recorded for the Northern Forest country type for all calving periods by the Cash Cow project (McGowan et al 2014). The impact of the extended inter-calving interval of the Northern Forest is evident in the difference between the P4M and annual pregnancy rates. (P4M is taken to be equivalent to a 13.5 month inter-calving interval.)

The Cash Cow project data for median reproduction performance in the Northern Forest country type is a reasonable estimate of the average performance for the hypothetical Katherine region herd model.

Table 133 Median reproduction performance for Northern Forest data (McGowan et al 2014)

Parameter	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

Table 134 shows the level of reproductive performance of each age class of females entered into the Breedcowplus model. The values retained produce a weaning rate of 54.53% once the PregTest macro is run. This is reasonably close to the Cash Cow project measure of "contributed a weaner" figure of 53% and is probably a satisfactory relationship, as the Cash Cow project did not set out to calculate a weaning rate as such. The Breedcowplus entries maintain the calf loss data provided by the Cash Cow project.

Table 134 Calving rate and death rate assumptions

Cattle age start year	1	2	3	4	5	6	7	8	9	10
Cattle age end year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
Expected conception rate (%)	0	70	20	75	75	75	70	70	65	60
Expected calf loss to weaning	0	16.4	9.5	11.8	11.8	11.8	11.8	13.7	13.7	13.7
Proportion of empties sold (%)	0	100	20	20	20	20	20	20	20	20
Proportion of pregnant sold (%)	0	0	0	0	0	0	0	0	0	0
Calves weaned/cows retained	0	83.6	21.5	69.6	69.6	69.6	65.7	64.3	60.3	56.3
Female death rate	6	6	6	6	6	6	6	6	6	6
Male death rate	6	6	6	6						

The mortality rates applied to steers and all females reflects the combined average mortality rate for the VRD, Gulf, Katherine and Sturt Plateau recorded by Henderson et al (2012) of 10.84% with allowance for the supplement regime applied on the modelled property. Note that mortalities are calculated in the herd model after sales are removed from the age class. Table 134 indicates that heifers were first mated as two year olds and 100% non-pregnant heifers were culled and sold. All other female age groups had 20% of the empty cows culled. Usually such cows are dry and empty and others are faulty.

6.2.6.6 Weaning dates and weights

Mating of the main breeder herd was continuous and the property had two rounds of mustering for weaning. The first round weaning occurred in May with the second round completed in October. Replacement heifers were mated for a three month period between mid-December and March each year with the calves weaned at the first round muster. The NT survey data indicates calves are weaned at the first round with an average weight of 174 kilograms and a minimum weight of 129 kilograms. The weaning weights at the second round average 129 kilograms with a minimum of 97 kilograms.

6.2.6.7 Steer sales

The target for steer sales was to sell the majority as live export steers at the end of the second wet season after weaning. In the base herd model, 81% of the turnoff of steers were sold between 24 and 35 months of age with the remainder sold between 36 to 35 months of age (Table 135). This allowed the steers to be slightly older and heavier at sale.

Table 135 Steer sales breakup

Maximum male turnoff age (integer)	**3**			
Steer or bullock age in months	**5 to 11**	**12 to 23**	**24 to 35**	**36 to 47**
Steer or bullock age group	0	1	2	3
Number available at start year	1291	1213	1141	204
Optional sales %			81%	
Sales at each age	0	0	924	204
Total steers and bullocks sold	1128	Average		$811.11

6.2.7 Herd structure and gross margin "without change"

The compiled herd model resulted in average breeder mortality rates of 6% and a weaning rate of 54.67% (weaners from all cows mated). The property produced about 2582 weaners from the 4722 females mated and sold 2038 head per annum. Cull female sales made up 44.2% of total sales. Table 136 shows the average herd structure of the baseline beef cattle enterprise.

Table 136 Herd structure (on average)

Age at Start of Rating Period	**Number Kept Whole Year**	**Number Sold**	**AE/Head Kept**	**AE/Head Sold**	**Total AEs**
Extra for cows weaning a calf	na	na	0.35	na	904
Weaners 5 months	2582	0	0.20	0.06	528
Heifers 1 year but less than 2	1213	0	0.46	0.27	561
Heifers 2 years but less than 3	770	371	0.65	0.33	621
Cows 3 years plus	3339	523	0.92	0.53	3361
Steers 1 year but less than 2	1213	0	0.48	0.24	587
Steers 2 years but less than 3	217	924	0.68	0.35	469
Bullocks 3 years but less than 4	0	204	0.76	0.38	77
Bulls all ages	189	28	1.43	0.83	293
Total number	9523	2050		Total AE	7400

The optimum age to sell cull heifers was identified as between 2-3 years old and the optimum age to finally cull mature breeders was 11-12 years of age. Breeder deaths numbered 247 or 6% of total cows and heifers mated on average. The majority of cull females were either 2-3 years old or 11-12 years old. Table 137 shows the gross margin calculations for the base herd. The capital value of the herd was taken to be the value net of sales when calculating the opportunity costs of the capital tied up in the herd.

Table 137 Section H: Calculation of gross margin and herd value

Parameter	$/Herd	$/A.E.	Capital Value of Herd (after sales)	$ Total
Net cattle sales	$1,486,140	$200.83	Value of cows, heifers and new spays	$3,437,185
Husbandry costs	$245,248	$33.14		$0
Net bull replacement*	$61,433	$8.30	Value of steers and bulls	$1,660,431
Gross Margin	$1,179,459	$159.39	Total	$5,097,616
GM less interest	$924,578	$124.94	Interest on herd capital 5%	$254,881

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

6.2.8 Herd investment model

The example property represents the "average" for the Katherine region and is therefore 147,000 hectares. It market value is assessed as $5.6 million bare of plant and livestock. Table 138 indicates the expected fixed cash costs for the next calendar year for the enterprise. Non-cash fixed costs of depreciation and the operator's allowance ($80,000per annum) were also included in the base herd financial analysis.

Table 138 Fixed cash costs

Item	Cost
Administration	$25,000
Power	$1,000
Freight	$35,000
Fuel and Lubricant	$65,000
Insurance -	$15,000
Materials	$6,000
Motor Vehicle Expenses	$10,000
Rates and Rents	$20,000
R & M General	$70,000
Wages	$105,000

Table 139 shows the current plant inventory for the beef enterprise and the calculation of depreciation.

Table 139 Plant inventory and depreciation allowance

Item	Market Value	Years to Replacement	Replacement Cost	Salvage Value	Subsequent replacement interval (years)	Depreciation Allowance
Toyota land cruiser ute	$15,000	3	$60,000	$15,000	7	$6,429
Toyota land cruiser ute	$30,000	6	$60,000	$20,000	10	$4,000
Nissan Patrol	$20,000	5	$60,000	$14,000	10	$4,600
Isuzu body truck	$80,000	7	$120,000	$20,000	10	$10,000
Hino	$40,000	10	$100,000	$20,000	15	$5,333
JD tractor	$50,000	15	$80,000	$25,000	20	$2,750
Cat grader	$150,000	15	$160,000	$80,000	15	$5,333
4 wheelers x3	$7,667	3	$12,000	$4,500	3	$2,500
1 x two wheeler	$4,000	3	$8,000	$2,000	5	$1,200
Workshop and saddlery	$100,000	10	$100,000		10	$10,000
Total	$496,667		$760,000			$52,145

Depreciation of assets was 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 was (Replacement cost minus salvage value) divided by the remaining life in years.

The replacement cost is an estimate of how much it would cost to replace the item if it were to be replaced now. The salvage value was estimated on the basis of the item being valued now but with the item in a condition equivalent to what it will be in when it is replaced. The total opening value of land, plant and improvements for the beef enterprise investment was assessed as $6,096,000. The enterprise had no debt in this analysis.

The investment analysis identified that the beef property returned about 5.71 % on the capital invested over the period. No allowance for any potential change in the change in the real value of the land asset was included.

6.3 Strategies that target herd performance

Producers and industry have been identified the strategies examined in this section of the report as potentially useful. They were assessed for their capacity to improve the performance of the Katherine beef production system 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 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 is, firstly, a guide to an appropriate method to assess alternative strategies aimed at improving profitability and resilience of a beef production system. Secondly, this report indicates the data required to conduct a comprehensive analysis and indicates 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.

6.3.1 Fixing a Phosphorus deficiency

Phosphorus deficiency occurs in cattle grazing many rangeland regions, including in northern Australia, due to low concentrations of P in soil, and thus pasture, and may severely reduce cattle growth and breeder productivity (Winks 1990; McCosker and Winks 1994). Phosphorus deficiency results in decreased pasture and energy intakes, poor growth, reduced fertility and milk production, and high breeder mortality. In addition to poor performance, in the absence of vaccination there is an increased risk of mortality from botulism associated with osteophagia (Dixon et al. 2017).

P deficiency of grazing cattle is usually addressed by P supplementation to provide the dietary requirements. Numerous experiments have reported large increases in voluntary intake of pasture (10-40%), growth rate (up to 100 kg/annum), reproductive performance expressed as weaning rates (10-30%), and weaner liveweights (10-40 kg) when P deficient cattle were fed additional P (Winks 1990, Wadsworth et al. 1990; McCosker and Winks 1994; Jackson et al. 2012). Large effects have also been observed on mortality and morbidity rates (Schatz and McCosker 2018). The biological response to P supplementation has often been related to the extent of a P deficiency and rangeland soil P has been classed as ranging from 'adequate' to 'acutely deficient' (McCosker and Winks 1994).

In growing cattle, P supplementation is most effective during the wet season when the pasture diet has adequate protein and energy (Winks 1990; Winter 1990; McCosker and Winks 1994; Jackson et al. 2012). While this is also generally true for reproducing breeders, breeders can mobilise P in body reserves, especially in bone, during pregnancy and lactation during dietary P deficiency and then replenish this P later in the annual cycle (Anderson et al. 2017; Dixon et al. 2017). This mechanism allows the reproducing breeder to benefit from P supplements fed during the dry season and provides a strategy for northern beef cattle production systems to address P deficiency even where it is not possible to feed P supplements during the wet season.

However, despite the extent of P deficiency across many northern Australian rangelands and the large responses to P supplementation, only a small proportion of cattle grazing these P deficient rangelands are effectively supplemented with P or otherwise managed to address P deficiency (Neithe 2011). Lack of information and understanding of the importance of P deficiency effects on cattle production, and of the profitability of P supplementation, are likely to be major reasons for the low rates of adoption of management to address nutritional deficiencies of P on commercial cattle properties (Dixon et al. 2011; Schatz and McCosker 2018).

This scenario uses the early results from a Phosphorus (P) supplementation trial currently underway on Kidman Springs Research Station (KSRS) (Schatz and McCosker 2018) combined with other available data to describe the impact of effective P supplements for cattle grazing Acutely P deficient soils in the Katherine region.

The heifers in the trial graze in two adjoining paddocks of native pasture that soil tests have confirmed are acutely P deficient (Colwell P <4 mg/kg). After weaning in mid-2014, 179 weaner heifers were allocated to two treatment groups (P+ or P-) and were then managed in exactly the same way except that their mineral loose lick supplement either contained P (P+) or did not (P-). The treatments swap paddocks each year to minimise paddock effects with the lick fed year round in troughs under supplement sheds. Table 140 shows the ingredients of the loose supplement lick fed to each treatment in each season.

Table 140 Supplement loose lick composition (as-fed basis)

Parameter	Wet season supplement	Dry season supplement	
	P supplemented	No P*	P supplemented
Urea (%)	0	25	25
Ammonium sulphate (GranAm) (%)	7.5	10	10
Ridley Biofos monocalcium phosphate (%)	42	0	25
Salt (%)	50	65	40
Crude protein (%)	9.5	84.5	84.5
P (%)	9.0	0	5.3

*Although the trial feeds N supplements to the P- herd, we will remove the cost of these supplements making the comparison between a herd that is supplemented with P (and N) in both the wet and dry and a herd that is not supplemented. The performance of the P- herd reflects this supplementation program (or lack of).

The heifers are mustered twice a year for data collection and were first mated at 2 year old (from late December 2015 to April 2016). Their performance has been observed from weaning and measurements are ongoing.

The trial results to date identify that:

- After first mating, the P+ treatment was 65 kg heavier (P<0.001), and was 4 cm taller (P<0.001) when compared to the P- treatment.
- Maiden heifer pregnancy percentage was 10% higher in P+ than P- (70% vs 60%, P= 0.12) with a similar prevalence of foetal and calf loss for both treatments (P+ = 20.6%, P- = 22.0%, P= 0.99).
- At the time of weaning their first calf (May 2017), the re-conception rate was 25% higher (P+ = 30%, P- = 5%, P<0.001) and average weight 120 kg heavier (P+ = 382 kg, P- = 262 kg, P<0.001) in P+ when compared to P-.
- Calves from P+ heifers were, on average, 34 kg heavier at weaning than those from P- (P+ = 178.3 kg, P- = 138.6 kg P<0.001),
- The P+ treatment produced an additional 31 kg of weaner per heifer mated (P+ = 95.7 kg/heifer, P- = 65.2 kg/heifer P<0.001)
- The prevalence of mortality of heifers up to 3.5 year old was significantly higher in P- (P+ = 1%, P- = 8%, P<0.001).

This and other data was applied to build a model of a "without change" property that has Acutely P deficient soils with no effective supplements currently fed and the same property with P supplements fed to stock at similar rates and times as fed in the trial.

This is analysis therefore has a <u>different starting or base scenario to our current regional model</u>. All stock on the P- property (the new base herd) now run on soils that are acutely P deficient and receive no effective supplements. The regional model applied elsewhere feeds P supplements, but in the dry season only.

The KSRS trial data and other sources (Jackson et al. 2012) were used to develop a growth path model for steers and heifers growing in an environment similar to the P- treatment and a growth path model for steers and heifers growing in a the same environment but receiving the P+ treatments. Tables 141 and 142 show the assumptions underpinning P- growth and Tables 143 and 144 show the assumptions for P+ growth.

Table 141 Expected steer and heifer growth path pre weaning P-

Average calving date	15/11/2018	
Average weaning date	16/05/2019	
Age at weaning (months)	6.0	months
Days to weaning	182	days
Male calf average daily gain birth to weaning	0.75	kilograms / day
Reduction in growth rate compared to steers	5%	
Heifer average daily gain birth to weaning	0.71	kilograms / day

Table 142 Expected post weaning steer and heifer growth rates P-

Month	Days	Steers kg/d	Steers kg / head	heifers kg/d	Heifers kg / head
Jan	31	0.5	15.5	0.475	14.7
Feb	28	0.6	16.8	0.57	16.0
Mar	31	0.55	17.1	0.5225	16.2
Apr	30	0.5	15.0	0.475	14.3
May	31	0.40	12.5	0.38	11.9
Jun	30	0	0.0	0	0.0
Jul	31	0	0.0	0	0.0
Aug	31	0	0.0	0	0.0
Sep	30	0	0.0	0	0.0
Oct	31	0	0.0	0	0.0
Nov	30	0	0.0	0	0.0
Dec	31	0.1	3.1	0.095	2.9
Total	365	0.22	80	0.21	76.0

The expected annual average growth rate of steers and heifers without the P supplement is about 80 kilograms per head per year.

Table 143 Expected steer and heifer growth path pre weaning P+

Average calving date	15/11/2018	
Average weaning date	16/05/2019	
Age at weaning (months)	6.0	months
Days to weaning	182	days
Male calf average daily gain birth to weaning	0.90	kilograms / day
Reduction in growth rate compared to steers	5%	
Heifer average daily gain birth to weaning	0.86	kilograms / day

Table 144 Expected post weaning steer and heifer growth rates P+

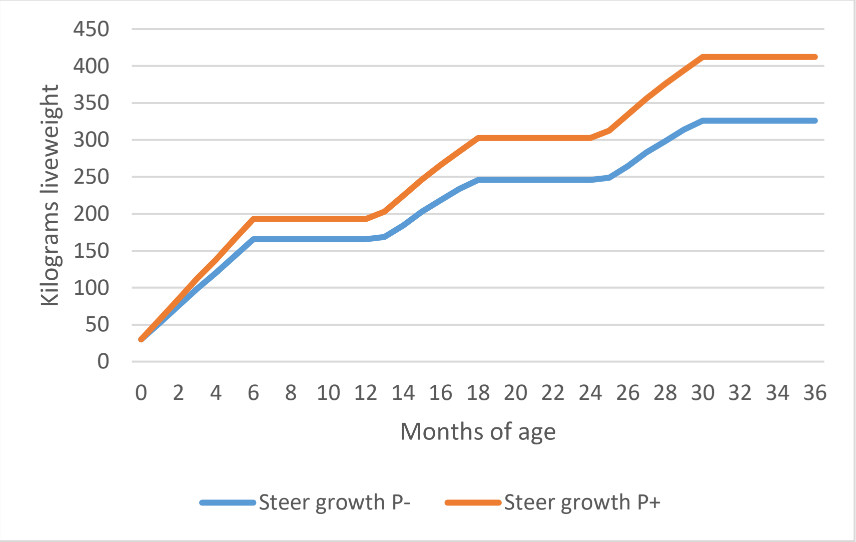
Month	Days	Steers kg/d	Steers kg / head	heifers kg/d	Heifers kg / head
Jan	31	0.7	21.7	0.665	20.6
Feb	28	0.7	19.6	0.665	18.6
Mar	31	0.7	21.7	0.665	20.6
Apr	30	0.6	18.0	0.57	17.1
May	31	0.6	18.6	0.57	17.7
Jun	30	0	0.0	0	0.0
Jul	31	0	0.0	0	0.0
Aug	31	0	0.0	0	0.0
Sep	30	0	0.0	0	0.0
Oct	31	0	0.0	0	0.0
Nov	30	0	0.0	0	0.0
Dec	31	0.3355	10.4	0.32	9.9
Total	365	0.30	110.00	0.29	104.5

The pre-weaning rate of growth chosen for the P- and P+ treatments in the alternative growth path models provides the lead of the P+ weaner steers with a 26 kilogram liveweight benefit at weaning, about that achieved by the weaners of the first calf heifers in the KSRS trial.

Subsequent to weaning, the expected average annual growth rate for steers and heifers fed the P supplement is about 30 kilograms per head per annum more than the steers and heifers that do not receive the P supplement. This reflects the level of difference revealed to date in the trial but is less than the benefit for P supplemented stock growing on acutely deficient classes of country predicted by Jackson et al. (2012).

The data in the above tables were combined to estimate the growth of steers from birth with and without P over the first 36 months. (Figure 25)

Figure 25 Steer and heifer growth paths with and without P supplement



The P supplemented heifers were 54 kilograms heavier in the modelled growth path at 24 months old, about the same as the weight differences identified in the trial for heifers at about the same age.

Table 145 shows the sale weights for the P- steers. The first cohort are expected to be sold in May when the lead steers average 30 months of age.

Table 145 Sale weights for P- steers

Average (mean) liveweight of group	326				Cutoff weight for first sale age	320
Standard deviation (SD) of weights	40				% of group above cutoff weight	56%
					Average weight of heavier group	354
In a "normal" distribution, 95%						
of individual weights will range from					Average weight of lighter group	290
248	kg to		404	kg	Expected gain if sold at next age	80
					Weight of lighter group by next age	370

Table 146 shows the sale weights for the P+ steers. The first cohort are expected to be sold in May when the lead steers average 18 months of age.

Table 146 Sale weights for P + steers

Average (mean) liveweight of group				303	Cutoff weight for first sale age	320
Standard deviation (SD) of weights				40	% of group above cutoff weight	35%
					Average weight of heavier group	346
In a "normal" distribution, 95%						
of individual weights will range from					Average weight of lighter group	280
225	kg to	381	kg		Expected gain if sold at next age	110
					Weight of lighter group by next age	390

Although the sale weights shown in Tables 145 and 146 are fairly similar, it must be remembered that the herd receiving the P supplements produces the first cohort steers of sale weight, on average, 12 months younger.

Table 147 indicates the reproduction and mortality rates compiled for the P- breeding herd model. Conception rates were adjusted to achieve an average weaning rate from total cows mated of about 45%. Calf loss has been maintained at the median level identified in the Cash Cow project (McGowan et al 2014) and mortality rates have been set at the median level for the region identified by Henderson et al (2012). The modelled conception rate in P- heifers (55%) was slightly lower than that achieved in the trial (60%) but the conception rate in 3-4 year old cows was higher than the trial to allow for the expected longer-term effect of the retention of empty heifers on conception rates in the 3-4 year old age group.

Table 147 Reproduction and herd mortality performance P-

Cattle age start year **Cattle age end year**	**Weaners** **1**	**1** **2**	**2** **3**	**3** **4**	**4** **5**	**5** **6**	**6** **7**	**7** **8**	**8** **9**	**9** **10**
Expected conception rate (%)	na	0.0	55.0	20.0	60.0	60.0	60.0	60.0	60.0	55.0
Expected calf loss (%)	na	0.0	16.4	9.5	11.8	11.8	11.8	11.8	13.7	13.7
Proportion of empties (PTE) sold (%)	na	0	25	5	5	5	5	5	5	5
Proportion of pregnants sold (%)	na	0	0	0	0	0	0	0	0	0
Calves weaned/cows retained (%)	na	0.0	51.8	18.9	54.0	54.0	54.0	54.0	52.8	48.6
Female death rate (%)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Male death rate (%)	10.0	10.0	10.0	10.0	10.0					

The breeder herd outputs for the P- herd are summarised in Table 148.

Table 148 Breeder herd outputs P -

Total female sales	448		
		Female/total sales	33.02%
Cows and heifers spayed or unmated	0	Turnoff/total herd	13.86%
Total cows and heifers mated	5117	Weaners/all cows mated	45.33%
Calves weaned	2319	Weaners/cows surviving	52.48%
Females mated and retained	4911	Weaners/cows mated & kept	47.23%

Table 149 shows the assumptions for conception and mortality rates applied in the P+ herd model. Conception rates were adjusted to achieve an average weaning rate from total cows mated of about 55%. This overall difference in weaning rates of 10% between the P- and P+ herds is similar to the early results of the KSRS trial but at the lower end of benefits predicted by Jackson (2012) for P supplemented breeders grazing land that is acutely deficient in P.

Calf loss rates have been left at the same level as applied in the P- herd model and mortality rates have been reduced by more than two thirds. Although Jackson (2012) does not indicate an impact of acute P deficiency on mortality rates, this critical oversight is being addressed in the KSRS trial where significant differences in rates of mortality /morbidity have already been recorded. To date, mortality rates have been reduced by more than 85% in the P+ treatment when compared to the P- treatment.

Table 149 Calving and death rate assumptions for the P+ herd

Cattle age start year **Cattle age end year**	**Weaners** **1**	**1** **2**	**2** **3**	**3** **4**	**4** **5**	**5** **6**	**6** **7**	**7** **8**	**9** **10**
Expected conception rate (%)	na	0.0	70.0	35.0	70.0	70.0	70.0	70.0	65.0
Expected calf loss (%)	na	0.0	16.4	9.5	11.8	11.8	11.8	11.8	13.7
Proportion of PTE sold (%)	na	0	100	50	25	25	25	25	25
Calves weaned/cows retained (%)	na	0.0	83.6	46.9	66.7	66.7	66.7	66.7	61.5

Female death rate (%)	3	3	3	3	3	3	3	3	3
Male death rate (%)	3	3	3	3	3				

The improved reproduction performance of the P+ herd allowed 100% of PTE empty 2-3 year old cows to be culled whereas only 25% were culled in the P- model. The final cow culling age for the P+ herd was maintained at 12-13 years, the same as the P- herd.

Table 150 shows the P+ female herd outputs. The average weaning rate has increased from about 45% to about 55%.

Table 150 Herd outputs P+

Total female sales	1081		
		Female/total sales	47.21%
Cows and heifers spayed or unmated	0	Turnoff/total herd	26.99%
Total cows and heifers mated	4616	Weaners/all cows mated	55.06%
Calves weaned	2542	Weaners/cows surviving	68.52%
Females mated and retained	3824	Weaners/cows mated & kept	66.46%

The change to rates of mortality and growth together with the reduction in the maximum cow culling age brought about by the implementation of the P+ supplementation regime significantly changes the structure of the herd grazing the acutely P deficient land over time.

Table 151 compares the herd structure with and without P and indicates the P+ herd will run about 500 fewer breeders but produce 223 more weaners on average. It will also produce 633 more cull females and 311 more sale steers on average than the P- herd.

Table 151 herd outputs P- and P+

Parameter	**P-**	**P+**
Total adult equivalents	7400	7400
Total cattle carried	9987	8589
Weaner heifers retained	1166	1272
Total breeders mated	5144	4619
Total breeders mated & kept	4936	3826
Total calves weaned	2331	2543
Weaners/total cows mated	45.33%	55.06%
Weaners/cows mated and kept	47.23%	66.46%
Overall breeder deaths	10.00%	3.00%
Female sales/total sales %	33.30%	47.21%
Total cows and heifers sold	451	1082
Maximum cow culling age	12	12
Heifer joining age	2	2
Weaner heifer sale & spay	0.00%	0.00%
One year old heifer sales %	0.00%	0.00%
Two year old heifer sales %	12.26%	37.64%
Total steers & bullocks sold	903	1209
Max bullock turnoff age	3	2
Average female price	$593.24	$715.88
Average steer/bullock price	$784.47	$820.98

Table 152 indicates the supplement costs incurred by the P+ treatment in the model. All other treatment costs and prices are identical on per head or per treatment in the “with” P and “without” P models.

Table 152 Supplement costs P+ treatment

Class fed and supplement type	Cost per ton landed	Intake grams /head /day	Number of days fed	Cost /head /annum
Wet season P lick yearlings	$1,340	40	150	$8.04
Wet season P lick Cows and Bulls	$1,340	80	150	$16.08
Dry season N+P lick weaners	$910	80	120	$8.74
Dry season N+P lick yearlings	$910	105	200	$19.11
Dry season N+P lick Cows and Bulls	$910	160	200	$29.12

The benefits of the supplementation program were implemented in the economic model over the first five years of the analysis to allow for the effects of the P supplement to flow through the herd although some benefits are likely after the first wet season of P supplementation. Supplement costs were fully incurred from the first year.

Table 153 shows the marginal return for supplementing a herd on a property that suffers an acute P deficiency with impacts similar to that encountered in the early stages of the KSRS trial and revealed by Jackson et al (2012).

Table 153 Marginal returns to fixing a P deficit

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$5,106,316
Annualised return (profit/year for analysis period)	$332,173
Period of analysis (years)	30
Peak deficit (with interest)	-$328,345
Year of peak deficit	1
Payback period (years)	2
IRR of "Change" advantage	152.13%

The large economic benefits determined for P supplements are greater than the estimated increase in herd gross margin for acutely P deficient cattle properties reported by Jackson et al. (2012); this was mostly due to a substantially greater estimated effect of P supplementation on the mortality rate of breeders in the present study.

The present study also indicated that the large estimated decrease in mortality in acutely P deficient herds due to P supplementation is a key driver of the improved profitability. For the Katherine region case study, this contributed about 33% of the total benefit of P supplementation on the herd gross margin. In situations where the mortality rate of unsupplemented breeders is as high as that implied by Schatz and McCosker (2018) the impact of P supplementation to reduce mortality on the economic performance of the herd would be substantially greater than that estimated in the present study.

An important related issue is that the regions in northern Australia with the highest rates of breeder mortality are generally also regions with the acutely P deficient soils and low levels of infrastructure, herd control and adoption of P supplementation (Henderson et al. 2012). P supplementation is obviously only one aspect of 'whole of property management' (Foran et al. 1990; Henderson et al. 2012) and substantial changes to herd and property management may often be required before any implementation of P supplementation. A further consideration is that it would be desirable to examine the economic returns from P supplementation on an individual property basis to account for specific aspects such as location, capability of the land systems, herd size and performance, input and output costs and current management.

Estimation of diet P intake by grazing cattle, and of their body P reserves, is difficult (McCosker and Winks 1994; Anderson et al. 2017; Dixon et al. 2016, 2017). This is especially difficult where paddocks include several major soil types. It has also been recognized that there are often difficulties when feeding loose mineral mix or feed-block supplements to achieve target intakes of a mineral such as P by grazing cattle. There is often poor acceptance of such supplements by cattle grazing wet season pastures, and usually high variability among animals and the presence of many non-eaters of supplement within herds (Dixon 1998; Dixon et al. 2003).

An additional consideration is that although the highest economic responses are expected to occur to P supplementation during the wet season this is often difficult to achieve in practice. Although the provision of N+P supplements during the dry season is less effective for cattle production and always provides lower economic benefit, this may be the only option for some commercial cattle property situations.

The economic analyses used in the present study clearly depend on:

- estimation of the production responses, particularly of breeder herds, to P supplementation under various sets of circumstances,
- identification of the P deficiency status of herds between and within annual cycles, and
- the cost of the implementation of an effective P supplementation program when and as planned.

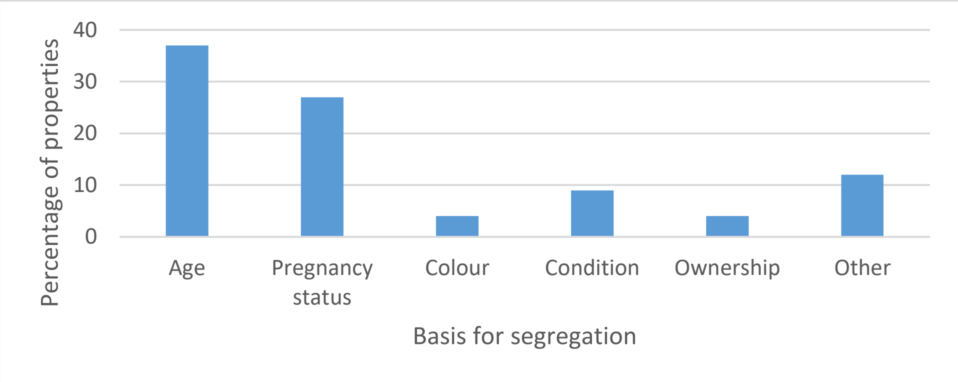
Each of these issues present challenges. As discussed above the estimated responses of cattle to P supplementation were based on the best expertise available and were deliberatively conservative in relation to much reported research. The estimates of the expected changes in cattle production adopted here and the associated economic responses are guidelines only.

6.3.2 Herd segregation

Cowley (2015) identified segregation of breeders allows producers to target management for a specific purpose. Age was the most important criterion for segregation according to producers responding to the 2010 NT Pastoral Industry Survey (Figure 26), but when taking into account the size of herds under segregation strategies, pregnancy status was the most significant criterion, with companies more likely to segregate breeders based on pregnancy diagnosis. While only 27% of surveyed properties segregated breeders into calving windows, these properties represented 46% of total cattle in the survey.

Privately owned properties were more likely to segregate based on age. 'Other' reasons for segregating breeders included breed, lactation status and females to be culled.

Figure 26 Percentage of properties that segregated breeders for different reasons (Cowley 2015)



Henderson et al (2012) identified segregation of breeders during the dry season as a significant factor associated with reduced mortality rates in females and males. Properties that practised segregation of breeders during the dry season had a 67% reduction in female mortality compared to those properties that did not segregate (reduction from 8.26% to 2.74%). They attributed this effect not to segregation per se but to the fact that properties that did segregate were likely to accompany this with additional strategies such as targeted supplementation or management of pastures to ensure optimal nutrition is provided to groups of animals with higher needs.

Henderson et al (2012) also identified segregation of large numbers of breeders during the dry season required careful planning, a high level of operational ability and a certain level of fencing and water infrastructure. Critical components for success include meeting breeder nutritional requirements with pasture management, supplementary feeding, and culling of empty dry females.

Braithwaite and de Witte (1999a) identified the key strategies underpinning a herd segregation system that segregated females on a lactation / pregnancy status basis. They identified the main advantages of that system as:

- The capacity to make early decisions in variable seasons.
- Available paddock nutrition and supplements can be targeted to the groups likely to make the best use.
- Cow and calf mortalities can be reduced.
- Cows aborting or losing calves can be identified.
- Mustering costs can be reduced as not all females will need to go through a second round weaning muster.

- Calves of similar ages are weaned together, potentially saving handling and feeding costs.

They saw the main constraints as:

- Time, effort and commitment are required to set up the system.
- Reorganising cattle management in a complex operation is not easy and requires a high level of cattle control and a sufficient level of development to allow segregation.
- The system requires lateral thinking, multi-skilled management and staff.

The survey data for the 2010 NT Pastoral Industry Survey (Cowley 2015) combines data for both segregated herds and unsegregated herds preventing any identification of the impact of segregation on the surveyed properties and no research data exists to allow estimates of the response of a herd to segregation. This makes it difficult to estimate the likely impacts of moving from an unsegregated system to a segregated system based on lactation /pregnancy status.

As a starting point, the estimates provided by Henderson et al (2012) for the impact on mortality and the estimates provided by Braithwaite and de Witte (1999a, 1999b) for the impact on supplementation and other herd management costs were applied to a modified Katherine region herd to reflect the potential impact of implementing a herd segregation system. The key assumptions were:

- Mortality rates in females 2-3 years and older fell from 9% to 3%,
- Steer mortality rates fell from 11% to 3.74%
- No other mortality rates changed
- Supplementation costs for retained females 2-3 years and older reduced by 10% from their present level
- Wages and salaries paid fell by 5% due to more efficient stock handling
- Reproduction efficiency did not change
- There was no change in weaning costs or other performance parameters of the herd or enterprise.

It was expected that capital expenditure will be required to implement a segregation system but the amount was unknown. The investment analysis tested the amount of capital that could be spent up front to gain the benefits listed above and still maintain a reasonable return. Table 154 shows the outputs of the segregated herd compared to the base herd.

Table 154 Herd outputs for segregated herd

Parameter	Modified base herd	Segregation impact
Total adult equivalents	7400	7400
Total cattle carried	9372	9043
Weaner heifers retained	1412	1389
Total breeders mated	5137	5020
Total breeders mated & kept	4872	4788
Total calves weaned	2825	2778
Weaners/total cows mated	54.99%	55.33%
Overall breeder deaths	9.00%	3.00%
Female sales/total sales %	39.90%	45.36%
Total cows and heifers sold	816	1101
Maximum cow culling age	9	9
Heifer joining age	2	2

One year old heifer sales %	8.24%	22.74%
Two year old heifer sales %	16.50%	16.50%
Total steers & bullocks sold	1229	1327
Max bullock turnoff age	2	2

The analysis implementing the segregation system contains a lag between investing in infrastructure and receiving the benefits. Table 155 shows the hypothetical investment returns from gaining the level of change in herd and enterprise performance identified previously.

Table 155 Investment analysis of an investment to convert a breeding herd to a segregated system

Expenditure	Period of analysis	NPV @ 5%	Annualised return	Peak deficit	Years to peak deficit	Payback period (years)
$100,000 capital	30	$2,843,406	$184,968	-$100,000	1	1
$500,000 capital	30	$2,462,454	$160,186	-$500,000	1	3
$1,000,000 capital	30	$1,986,263	$129,209	-$1,000,000	1	7
$2,000,000 capital	30	$1,033,882	$67,256	-$2,000,000	1	15

It appears that a substantial amount of capital could be spent and still achieve a sound return if the assumed benefits could be gained and maintained.

The lack of research data underpinning the assumptions makes the results quite uncertain. It appears that the returns indicated are, as identified by Henderson et al (2012) and Braithwaite and de Witte (1999a, 1999b), the cumulative returns to better and more timely management of a number of aspects of the breeding herd. It has been shown on a number of occasions (Holmes 1990, Chudleigh et al 2016) that herd management strategies that simultaneously affect a number of production parameters can provide significant economic benefit and this analysis confirms that aspect of beef production in northern Australia. The benefits are derived from an appropriate investment in infrastructure that allows more control over the breeding herd and a manager capable of implementing (and adjusting as required) a complex cattle management system.

The investment returns indicated in Table 155 may also be accessible for a number of strategies that simultaneously have impact on a number of herd performance parameters and enterprise costs.

Strategies like controlled mating, one step on from this segregation system, when combined with improved nutrition management may have a similar impact if significant costs can be saved and a number of herd performance parameters improved simultaneously. The final benefits completely depend upon the difference in performance between the two systems, the idiosyncrasies of the implementation phase and the cost of achieving the additional benefits.

6.3.3 Home bred herd bulls

The potential economic impact of selecting breeding bulls from the male weaners of a commercial beef herd was tested using the Katherine herd model.

The current complement of herd bulls in the regional model is about 202 bulls, with replacements entering the herd as two year olds purchased for an average landed cost of $2,500. About 40 replacement herd bulls were required each year at a cost of $100,000 to meet the ongoing needs of the breeding herd. The herd bulls were kept for five years with the annual mortality rate expected to average 5%. The percentage of bulls used in the breeding herd is expected to continue at 4% if the change to BYO bulls is made.

The breed your own (BYO) bull's scenario consists of identifying approximately 80 male weaners at the first round weaning born during the October to December calving period from selected cows, keeping them to yearling age when 50% will be culled and sold. The remainder will enter the breeding bull herd as herd bulls. Culled herd bulls of a mature age will sell to the abattoirs for the same average value with or without home bred herd bulls being retained.

The scenario relies upon the maintenance of accurate records for the reproductive performance of heifers over their first two mating's so that young cows with better reproductive performance can be identified, segregated and their progeny identified. These young females will be used to maintain a group of about 400 cows to produce the calves from which the weaner bulls will be selected.

The bull selection process includes some effort to ensure that yearling bulls pass an examination for the traits identified by Burns et al (2014). The additional costs expected to be incurred by the selection process were included in the budget at $100 per weaner bull retained or about $8,000 per annum. Additional expenses incurred in maintaining the records for the heifers, segregated breeders and selecting the weaner bulls are expected to be about $50 per cow retained in the segregated herd or about $20,000 per annum.

Cull yearling bulls were sold at the same average live export price for steers of the same weight and $20,000 worth of fencing and water infrastructure was required to maintain the weaner and yearling bulls separate until they enter the bull herd.

The first group of weaner bulls will be retained in the first year of the analysis but they will not enter the bull herd until the third year. Table 156 shows the marginal return on investment.

Table 156 Marginal return on investment in selecting home bred bulls

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$424,620
Annualised return (profit/year for analysis period)	$27,622
Period of analysis (years)	30
Peak deficit (with interest)	-$78,400
Years to peak deficit	2
Payback period (years)	3
IRR of "Change" advantage	39.93%

The investment was paid back by year three with about $28,000 per annum added to the profit of the enterprise, on average, over the 30 years of the investment. The return on the extra funds invested was about 40% per annum. The key assumptions were that the bull / cow mating ratio would be maintained and that no aspect of herd performance (reproductive or growth) would be impacted by the change.

6.4 Strategies that target the female component of the herd

6.4.1 Heifer culling strategy

The current heifer culling strategy focusses upon selling 24-36 month old heifers post their first mating. Less than 4% of replacement heifers are culled prior to mating. These cull heifers are then sold with any non-pregnant heifers from the same age cohort in May of each year once pregnancy testing is complete.

This scenario considers the impact of culling more heifers prior to mating (20%) with a lighter cull (50%) on pregnancy status after the first mating. To do this, the Katherine starting herd model was adjusted to cull 50% of PTE 3-4 years' old heifers and cull about 20% prior to mating. (See Table 157)

Table 157 Culling assumption for 2-3 year old heifers

Cattle age start year	Weaners	1	2	3	4	5	6	7	9
Cattle age end year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**10**
Expected conception rate (%)	na	0.0	70.0	20.0	75.0	75.0	75.0	70.0	65.0
Expected calf loss (%)	na	0.0	16.4	9.5	11.8	11.8	11.8	11.8	13.7
Proportion of PTE sold (%)	na	0	50	15	20	20	20	20	20
Proportion of pregnant sold (%)	na	0	0	0	0	0	0	0	0
Calves weaned/cows retained (%)	na	0.0	68.8	20.6	69.6	69.6	69.6	65.7	64.3

Table 158 indicates that the herd gross margin could be reduced by about $42,000 per annum if the focus is on increasing the cull rate on 2-3 year old heifers prior to mating and reducing the cull rate after mating.

Table 158 Analysis of changing the cull rate on 2-3 year old heifers

Parameter	Starting herd	Heifer culling
Total adult equivalents	7400	7400
Total cattle carried	9523	9495
Weaner heifers retained	1291	1260
Total breeders mated	4722	4603
Total breeders mated & kept	4109	4211
Total calves weaned	2582	2520
Weaners/total cows mated	54.67%	54.74%
Overall breeder deaths	6.00%	6.00%
Female sales/total sales %	44.22%	43.88%
Total cows and heifers sold	894	861
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year old heifer sales %	33.59%	34.75%
Total steers & bullocks sold	1128	1101
Max bullock turnoff age	3	3
Average female price	$639.34	$639.13
Average steer/bullock price	$811.11	$811.11
Capital value of herd	$5,097,616	$5,098,558
Imputed interest on herd value	$254,881	$254,928
Net cattle sales	$1,486,140	$1,442,659
Direct costs excluding bulls	$245,248	$245,174
Bull replacement	$61,433	$59,887
Gross margin for herd	$1,179,459	$1,137,597
GM after imputed interest	$924,578	$882,669

It must be remembered that the Optimise Female sales macro only looks at the best way to sell surplus heifers once the post mating sales have been entered. It does not consider whether culling prior to mating or after mating is more efficient and such strategies will need to be tested separately. In this case, and even though a relatively minor change was made to the way heifers are culled, the efficiency of the restructured herd was less than the base herd, reducing profit.

Table 159 indicates the marginal or extra return generated by changing the heifer culling strategy. The implementation to the change to the heifer culling strategy is quite quick and therefore produces a similar Annualised return to the average gross margin shown in Table 158 that reflects the full implementation of the change.

Table 159 Marginal returns for the changed heifer culling strategy

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$703,386
Annualised return (profit/year for analysis period)	-$45,756
Period of analysis (years)	30
Peak deficit (with interest)	-$1,969,428
Year of peak deficit	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

6.4.2 Feeding first calf heifers to change reproduction efficiency

In this scenario, a change in the re-conception rate of first calf heifers was sought by improving their bodyweight prior to calving. The median data from Cash Cow identifies that 43% of first lactation heifers are likely to conceive in the 3-4 year age group in this region. The Katherine herd model constructed for this analysis applies a 20% conception rate in first calf heifers, half that recorded by Cash Cow for the region, but matching the modelled conception rate with the findings of Schatz (2010) for heifer mating weight and expected conception rate.

The parameters of this 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 in the Victoria River District (VRD) of the Northern Territory.

The study found that when Brahman first-lactation heifers were supplemented pre-partum with high protein supplements (at a rate of 0.4% of liveweight per day):

- Foetal and calf loss between pregnancy diagnosis and weaning averaged 13% over the three year groups with no significant differences in foetal- and calf-loss rates between treatments in any of the year groups or when averaged over the three year groups
- Re-conception rates in first-lactation heifers not given a protein supplement before calving were averaged 22% with a range of 9–39%.
- On average, unsupplemented heifers lost 1.2 kg over the dry season before calving, and lost a further 35.9 kg between September and the weaning muster in May (that is, during lactation).
- Supplemented heifers gained an average of 19.5 kg over the pre-calving dry season and lost a similar amount of weight (38.5 kg) as the unsupplemented heifers between calving and weaning.
- Re-conception rates in the trial were an average of 42% higher in the supplemented than the unsupplemented treatment (23% to 65%)

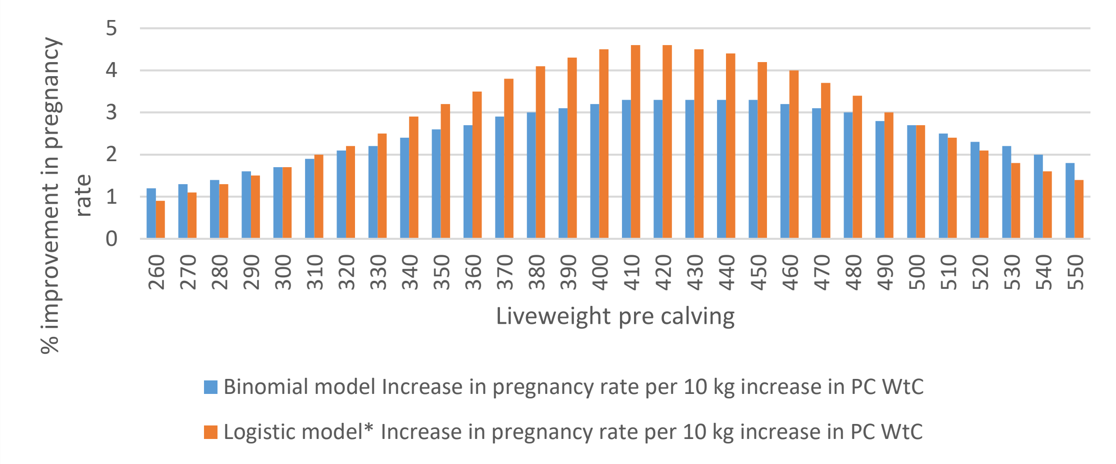
The supplemented group in the trial was fed a protein supplement over the latter part of the dry season leading up to calving. This supplement was fed out twice a week (3 or 4 days apart) into troughs in the paddock and feeding continued until the start of the wet season (which was judged to have occurred once 50 mm of rain had been received and green grass was visible).

Both treatment groups were given ad libitum access to inorganic supplement 'loose mixes' in the dry season (50% salt, 20% urea, 20% Kynophos and 10% Gran-am) and the wet season (50% salt, 35% Kynophos and 15% Gran-am).

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.

Although the trial groups averaged a 42% improvement in conception rates, analysis of the trial data identified that the predicted pregnancy rate will change by between 4% and 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 kilograms. (Figure 27)

Figure 27 Predicted pregnancy rates at different pre calving weights (corrected for stage of pregnancy) and the predicted increase in pregnancy rate for each 10kg increase in PC Wt^C (Schatz 2010)

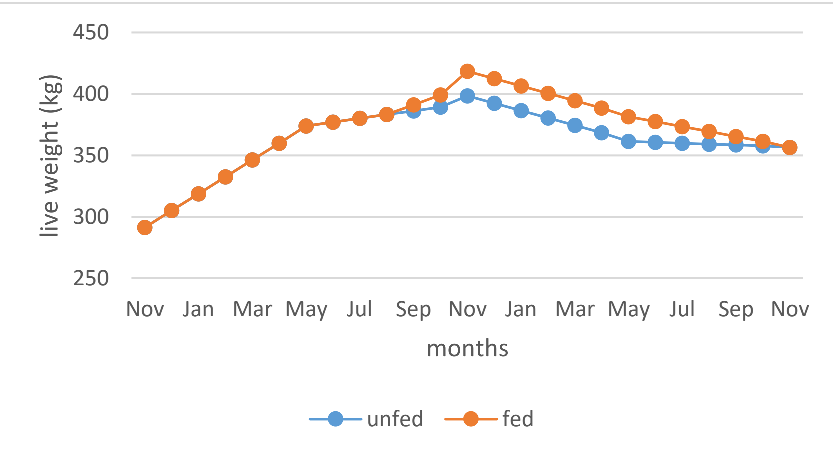


*The predictions of pregnancy rate using the logistic model are likely to be more accurate than the predictions from the binomial model (Schatz 2010).

The growth model for the Katherine region base herd identifies that first calf heifers are likely to average about 340 kilograms liveweight just prior to calving. The analysis of trial results identifies that feeding these heifers so they are 20 kilograms heavier in bodyweight at the same time will lift their subsequent conception rates from 20% to about 26%. (See Table 8 page 41 of Schatz 2010).

Figure 28 below indicates the expected impact on pre-calving weight of feeding first calf heifers prior to calving. The body weight of heifers post the feeding exercise has a number of potential outcomes but the most likely was identified here. The fed heifers are expected to lose their bodyweight advantage by the end of the following dry season (fed line).

Figure 28 Growth path of fed and unfed first calf heifers



Schatz (2010) identified that while *"it may be quite profitable to supplement some weight ranges of heifers, some heifers will be heavy enough without supplementation and some will be too light to make a target joining weight even with supplementing (and so supplementary feed would be wasted in these cases)"*.

The existing conception rates for heifers and age groups older than the 3-4 year age group were maintained at the same level. Feeding the protein supplement was considered unlikely to change the overall average sale weight of culls cows from the herd or the grazing pressure applied by the fed group so the sale weights and paddock weights were maintained.

Table 160 shows the new female herd structure once the protein supplementation of the 2-3 year old first calf heifers has been implemented and their conception rates have changed from 20% to 26%. The overall weaning rate for the herd changes from 54.67% to 55.56%. The final age of cow culling is not changed to maintain the same basis for culling mature females in the without change and with change models.

Table 160 Female herd structure with protein supplement fed to 2-3 year old PTIC heifers

Parameter	Base herd	Herd with first calf heifers fed protein supplement
Total cows and heifers mated	4722	4679
Calves weaned	2582	2600

The breeder herd with the heifer feeding strategy produced about 18 more weaners per annum on average and total female sales increased by 10 per annum due to the improved efficiency of the breeding herd - without changing the grazing pressure exerted by the herd.

Table 161 shows the calculation of the expected feeding cost per head.

Table 161 Feeding costs for PTIC 2-3 year age group heifers

Number of PTIC heifers to be fed		756			
Average body weight		340	kg		
Food consumed	0.40%	1.36	kg per head per day		
Number of days to be fed		100			
Total intake of protein		136	kg per head		
Cost of protein supplement		$750	per ton landed		
Total protein supplement fed		103	Tons		
Total cost of protein		$77,112	total supplement cost		
Cost of feeding out					
Fed out	2 times a week		28.57	times fed	
Wages and fuel for 1 feeding out		$200			
Total cost of feeding the protein		$5,714			
Total cost of the supplement and the feeding out					**$82,825**
Cost per head fed					$109.56
Capital cost of the feed troughs					$20,000

Capital expenditure of $20,000 was required for troughs and feeding out equipment.

Table 174 shows the predicted investment returns for feeding protein supplement to first lactation heifers. It appears that the investment will reduce the average annual profit of the enterprise by about $70,000 per annum. The feeding program was undertaken in the first year and the benefits were lagged by one year.

Table 162 Investment returns for feeding protein supplement to first calf heifers

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$1,075,723
Annualised return (profit/year for analysis period)	-$69,977
Period of analysis (years)	30
Peak deficit (with interest)	-$3,001,513
Years to peak deficit	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

This result relies upon the relationship between the extra costs feeding program and the extra benefits generated by the improved reproductive efficiency of the breeder herd. Whether a lower cost of supplement would improve the returns was tested by reducing the cost by half. Table 175 shows the investment returns for feeding a protein supplement to first lactation heifers at half the cost for the protein supplement. The investment was still predicted to reduce the annual profit of the enterprise significantly.

Table 163 Investment returns for protein supplementation of first lactation heifers at half the cost of protein supplement

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$482,392
Annualised return (profit/year for analysis period)	-$31,380
Period of analysis (years)	30
Peak deficit (with interest)	-$1,339,387
Years to peak deficit	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

6.4.3 Genetic selection to change the efficiency of the female herd

Implementing genetic selection to change the weaning rate of breeders has also been proposed as a way of improving herd reproduction efficiency. Research has identified that genetic selection for improved reproduction efficiency is possible. Examples of relevant research results include:

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

The expected benefits potentially arising from the changes in reproduction efficiency described by Burns et al (2014) can be tested using the models built for the Katherine region.

The base herd (that maintained its expected weaning rate over time) was compared to:

- a herd that changed its breeding bull herd in the first year to bulls with genes expected to improve conception rates by 6% over time (Year 1 change; Scenario 1) and,
- a herd that replaced the herd bulls as they came due with genetically different bulls - also expected to improve the breeder conception rates by 6% over time (Gradual replacement; Scenario 2)

Sub-scenarios were investigated within each of these two over-arching scenarios.

A key assumption underlying Scenario 1 was that the property manager converted all of the current breeding bull herd to one with different genes in the first year with the first group of calves with the different genes born in the second year. This was due to the calendar year being used in the herd budget and the first crop of calves after the changeover of bulls being born, on average, around November of the first year arising from the mating prior to the changeover of the herd bulls. On this basis, it was Year 4 before heifers with different genes were first mated as 2-3 year olds. Additional capital was required and more than a decade was taken to fully implement the change. The capital cost of the changeover was incorporated in the first year of the analysis and was due to the sale of the existing bull herd not covering the costs of the replacement bull herd.

Scenario 1a purchased replacement bulls with different genes costing the same as the average cost ($2,500) used in the ‘without change’ herd but there was a net cost to change the bull herd over in the first year (Year 1 change, same cost; Scenario 1a). The net capital cost of the changeover of bulls at the beginning of the investment period was $257,500 (206 x $2,500 for the new bulls less 206 x $1,250 for the old ones).

Scenario 1b assessed whether a producer could pay, more, on average, for replacement bulls by spending $500 more per bull (Year 1 change, $500 more; Scenario 1b). The changeover cost to establish the bull herd became $360,500 (206 x $3,000 for the new bulls less 206 x $1,250 for the old ones) and the ongoing cost of replacement bulls became $3,000 each.

Scenario 1c considered the uncertainty around the paddock level change in conception rates by changing conception rates by 4% instead of 6%. This was tested at the same average purchase price for bulls as paid by the base herd (Year 1 change, 4% CR; Scenario 1c).

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 2a, 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 (Gradual replacement, same cost; Scenario 2a). 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 of no additional costs prevented the identification of the genetically different heifers and 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.

Scenario 2 was also tested for the impact on risk and returns of paying $500 per head more for replacement herd bulls (Gradual replacement, $500 more; Scenario 2b).

The conception rates applied in the Katherine starting herd in previous analyses were modified to reflect the median data recorded by the Cash Cow project. The average weaning rate of the Katherine starting herd was 54.67% and this changed to 54.73% when the Cash Cow median conception rate for the Northern Forest were applied. This was even though the conception rates of first calf heifers was increased from 20% to 43%.

For all scenarios, the starting level of reproduction performance prevented all females that did not show as pregnant from being culled. That is, the mature breeding females only had 5% of cows that showed as non-pregnant culled and only 50% of non-pregnant heifers were culled after their first mating. Most non-pregnant mature females had to be retained in the herd until they were last mated at 9-10 years of age to maintain the herd in a steady state. Increasing the maximum cull age would allow slightly heavier culling of non-pregnant younger females but this would reduce the economic performance of the herd given that the final mating age of 9-10 years was identified as the economic optimum for this version of the Katherine herd.

The change in reproduction efficiency was implemented in the model by changing conception rates in each age group of females by 6% as the different genes were incorporated over time. Calf loss and mortality rates were unchanged and the model maintained the same culling strategy for heifers and overall grazing pressure as reproductive efficiency changed. In this way, the model only reflected the underlying impact provided by the change in conception rates.

6.4.3.1 Replace the bull herd in the first year (Year 1 change, same cost; Scenario 1a)

Table 164 indicates the change in weaning rate and other factors as the selected genes flowed through the breeding herd.

Table 164 Modelled steps in genetic change of conception rate (6% change) and herd structure, bulls exchanged first year (Year 1 change, same cost; Scenario 1a)

Factor	Base herd	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total adult equivalents	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400
Total cattle carried	9,372	9,359	9,361	9,363	9,365	9,367	9,368	9,370
Weaner heifers retained	1,412	1,428	1,444	1,458	1,470	1,480	1,490	1,498
Total breeders mated	5,145	5,095	5,067	5,044	5,023	5,005	4,988	4,974
Total breeders mated & kept	4,872	4,869	4,846	4,827	4,809	4,793	4,779	4,766
Total calves weaned	2,825	2,856	2,888	2,915	2,939	2,961	2,980	2,996
Weaners/total cows mated (%)	54.9	56.1	57.0	57.8	58.5	59.2	59.7	60.2
Weaners/cows mated and kept (%)	58.0	58.7	59.6	60.4	61.1	61.8	62.4	62.9
Overall breeder deaths (%)	9	9	9	9	9	9	9	9
Female sales/total sales (%)	39.9	40.1	40.4	40.6	40.7	40.9	41.0	41.1

Total cows and heifers sold	816	834	851	866	879	891	902	911
Maximum cow culling age	9	9	9	9	9	9	9	9
Heifer joining age	2	2	2	2	2	2	2	2
One year old heifer sales (%)	8.2	12.5	14.0	15.5	16.5	17.4	18.5	18.9
Two year old heifer sales (%)	16.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Total steers and bullocks sold	1,229	1,243	1,257	1,269	1,279	1,289	1,297	1,304
Maximum bullock turnoff age	2	2	2	2	2	2	2	2

Table 164 indicates that the weaning rate for the overall breeding herd lifts by about 5.34% over 10 years when conception rates are incrementally increased by 6%. Change of more than this in the weaning rate is unlikely as all age groups of females have the different genes for reproduction efficiency by the end of the decade. The average weaning rate does not change by 6% due to a change in herd structure causing a proportional increase in the number of first calf heifers in the herd. This group of females has lower conception rates, and even though these low rates are increased by 6%, they are still relatively low and cause the 6% increase in herd weaning rate target to be missed. It can be seen that the breeding herd with the changed reproduction efficiency in Year 10 after the implementation of the change sells 75 more steers and 95 more cows and heifers after mating about 170 fewer breeders at the same grazing pressure.

Table 165 indicates the marginal returns arising from incurring the bull changeover costs ($257,500) at the start of the investment period and then continuing the analysis for three decades. The property is likely to be better off over the three decades if the investment in genes to change conception rates by 6% was implemented as predicted. The beef enterprise takes some time to recoup the investment (15 years) but the marginal return on funds invested by Year 30 is sufficient to earn about 9% on the capital invested in changing the bull herd. It appears that if bulls capable of providing the level of gains applied in the scenario analysis were available at the same price as bulls currently purchased, their introduction would eventually improve economic performance over the three decades after the first use of the bulls.

Table 165 Marginal returns of genetic change of conception rate in the Katherine region (Year 1 change, same cost; Scenario 1a)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$345,322
Annualised NPV	$22,464
Peak deficit (with interest)	-$225,425
Years to peak deficit	5
Payback period (years)	15
IRR of 'change' advantage	9.38%

6.4.3.2 What if the genetically different bulls cost more? (Year 1 change, $500 more; Scenario 1b)

Table 166 shows the investment returns where $500 more per bull on average was paid to achieve the genetic change. The investment generated a positive return of about 5% per annum and the investment did not breakeven for 19 years. Paying a premium for the genetically different bulls halved the return on funds invested and significantly extended the payback period. Hence, seed stock producers would need to be careful about incurring significant extra costs to identify the genetically different bulls if they wanted to recoup those funds when the bulls were sold.

Table 166 Marginal returns of genetic change of conception rates with $500 more paid for bulls (Year 1 change, $500 more; Scenario 1b)

Factor	Value
Period of the analysis (years)	30

Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$247,226
Annualised NPV	$16,082
Peak deficit (with interest)	-$356,882
Years to peak deficit	5
Payback period (years)	19
IRR of 'change' advantage	5.32%

6.4.3.3 What if the change in conception rates was 4%, not 6% (Year 1 change, 4% CR; Scenario 1c)

Table 167 shows the incremental change in herd reproduction efficiency over time if a 4% improvement in conception rates was achieved, not 6%.

Table 167 Modelled steps in genetic change of conception rate (4% change) and herd structure, bulls exchanged first year (Year 1 change, 4% CR; Scenario 1c)

Factor	Optimised	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total adult equivalents	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400
Total cattle carried	9,372	9,363	9,365	9,366	9,367	9,368	9,369	9,371
Weaner heifers retained	1,412	1,423	1,434	1,443	1,451	1,458	1,465	1,470
Total breeders mated	5,145	5,108	5,090	5,075	5,061	5,048	5,037	5,027
Total breeders mated and kept	4,872	4,870	4,855	4,842	4,830	4,819	4,810	4,801
Total calves weaned	2,825	2,846	2,867	2,886	2,902	2,916	2,929	2,940
Weaners/total cows mated (%)	54.90	55.71	56.33	56.86	57.34	57.77	58.15	58.49
Overall breeder deaths (%)	9	9	9	9	9	9	9	9
Female sales/total sales (%)	39.9	40.1	40.2	40.4	40.5	40.6	40.7	40.7
Total cows and heifers sold	816	828	840	850	859	867	874	880
Maximum cow culling age	9	9	9	9	9	9	9	9
Heifer joining age	2	2	2	2	2	2	2	2
One year old heifer sales (%)	8.2	11.1	12.2	13.1	13.9	14.5	15.1	15.6
Two year old heifer sales (%)	16.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
Total steers and bullocks sold	1,229	1,239	1,248	1,256	1,263	1,269	1,275	1,280
Maximum bullock turnoff age	2	2	2	2	2	2	2	2

Table 167 indicates that a 4% change in conception rates brought about by genetically different bulls changed the weaning rate by 3.59% (54.9 to 58.49%). The number of females sold increased by 64 and the number of steers sold increased by 51. Table 168 indicates that reducing the change in conception rates from 6% to 4% significantly reduced the economic performance of the investment.

Table 168 Marginal returns of genetic change of conception rate in the Katherine region (4% change); (Year 1 change, 4% CR; Scenario 1c)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV of 'change' advantage	$165,219
Annualised NPV	$10,748
Peak deficit (with interest)	-$258,062
Years to peak deficit	5
Payback period (years)	19
IRR of 'change' advantage	5.06%

6.4.3.4 What if the bull change-over costs were not incurred? (Gradual replacement, same cost; Scenario 2a)

This scenario replaced the herd bulls as they came due, at the same cost as for the 'without change' herd, and required that no additional costs be incurred to identify heifers produced by the new bulls. Table 169 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 13 before the breeder herd is converted.

Table 169 Incremental steps in genetic change of conception rate with bulls replaced over time (Gradual replacement, same cost; Scenario 2a)

Parameter	First mating	Second mating	Third mating	Fourth mating	Fifth mating
Total herd bulls	205	205	205	205	205
Bulls with different genes	41	82	123	164	205
Mature cows mated to different bulls	1,027	2,055	3,082	4,110	
Number that conceive	699	1,397	2,096	2,767	
Number that wean a calf	616	1,232	1,849	2,441	
Heifer weaners produced	308	616	924	1,220	
Yearling heifers	266	532	797	1,053	
Two year heifers pre culling	250	500	749	989	
Heifers with different genes mated	250	500	749	989	
Total heifers mated	1,145	1,145	1,145	1,145	
Percentage of heifers with different genes	21.8%	43.6%	65.4%	86.4%	100%
Improvement in conception rate of mated heifers	1.3%	2.6%	3.9%	5.2%	6.0%
Improvement in conception rate of 3-4 year heifers		1.3%	2.6%	3.9%	5.2%
Improvement in conception rate of 4-5 year cows			1.3%	2.6%	3.9%
Improvement in conception rate of 5-6 year cows				1.3%	2.6%
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 170 shows the change in herd structure over the 13 years taken to implement the strategy.

Table 170 Modelled steps in genetic change of weaning rate and herd structure with bulls replaced over time (Gradual replacement, same cost; Scenario 2a)

Parameter	Base	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
Total adult equivalents	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400	7,400
Total cattle carried	9,372	9,369	9,367	9,365	9,363	9,363	9,365	9,367	9,368	9,369	9,366
Weaner heifers retained	1,412	1,416	1,423	1,433	1,445	1,458	1,470	1,481	1,489	1,494	1,492
Total breeders mated	5,137	5,128	5,112	5,092	5,068	5,043	5,022	5,004	4,990	4,981	4,975
Total breeders mated & kept	4,872	4,872	4,866	4,856	4,842	4,825	4,808	4,792	4,781	4,773	4,768
Total calves weaned	2,825	2,832	2,846	2,865	2,890	2,917	2,941	2,962	2,977	2,988	2,997
Weaners/total cows mated (%)	54.99	55.22	55.66	56.27	57.03	57.84	58.56	59.19	59.66	59.99	60.24
Weaners/cows mated and kept (%)	57.98	58.13	58.48	59.01	59.69	60.45	61.17	61.81	62.28	62.60	62.86
Overall breeder deaths (%)	9	9	9	9	9	9	9	9	9	9	9
Female sales/total sales (%)	39.90	39.95	40.06	40.21	40.39	40.58	40.75	40.89	41.00	41.07	41.13
Total cows and heifers sold	816	820	828	839	852	867	880	892	900	906	911
Maximum cow culling age	9	9	9	9	9	9	9	9	9	9	9
Heifer joining age	2	2	2	2	2	2	2	2	2	2	2
One year old heifer sales (%)	8.24	9.18	10.47	12.03	13.80	15.40	16.52	17.46	18.14	18.59	18.59
Two year old heifer sales (%)	16.50	15.85	15.20	14.55	13.90	13.50	13.50	13.50	13.50	13.50	13.50
Total steers & bullocks sold	1,229	1,232	1,238	1,247	1,258	1,269	1,280	1,289	1,296	1,300	1,304
Maximum bullock turnoff age	2	2	2	2	2	2	2	2	2	2	2
Average female price	$494.09	$492.74	$490.73	$488.21	$485.32	$482.59	$480.55	$478.85	$477.65	$476.86	$475.26
Average steer/bullock price	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88	$681.88

Table 171 indicates that the strategy may generate sound economic benefits over the 30 year investment horizon.

Table 171 Marginal returns for investment in genetically different bulls to improve breeder fertility with no additional costs (Gradual replacement, same cost; Scenario 2a)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
NPV of "Change" advantage	$712,184
Annualised NPV	$46,329
Peak deficit (with interest)	n/a
Payback year	n/a
Payback period (years)	n/a

6.4.3.5 What if the genetically different bulls cost more? (Gradual replacement, $500 more; Scenario 2b)

Table 172 shows the investment returns where $500 more per bull on average was paid with the strategy of replacement of bulls as they come due. The investment generated a positive return of about 18% per annum and the investment did not breakeven for 7 years. Paying a premium for the genetically different bulls produced an extended payback period. Hence, seed stock producers would need to be careful about incurring significant extra costs to identify the genetically different bulls if they wanted to recoup those funds when the bulls were sold.

Table 172 Marginal returns of genetic change of conception rates with $500 more paid for bulls (Gradual replacement, $500 more; Scenario 2b)

Factor	Value
Period of the analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$401,842
Annualised NPV	$26,140
Peak deficit (with interest)	-$109,365
Years to peak deficit	7
Payback period (years)	11
IRR of 'change' advantage	18.56%

6.4.3.6 Summary and discussion of results

Immediately and completely replacing the current bull herd with bulls that change reproduction efficiency in the Katherine herd model appeared unlikely to significantly improve economic performance within the first two decades after the investment due to the minimum of a 15-year payback period. Herd managers may eventually improve economic performance over three decades if they fully replaced their current bull herd with bulls showing strong indicators for fertility but paid no more for them.

Converting to a herd with different genes for fertility, by replacing all bulls in Year 1 of the analysis, resulted in a positive annualised NPV of $22,464 but increased financial risk as indicated by the peak deficit of -$225,425. Replacing the bulls over the first 4 years with no additional costs improved the profitability of the property at low risk. Incurring an additional $500 per head to access bulls with different genes almost halved the returns compared to the scenario that replaced bulls over time at no additional cost.

After having considered the current analysis and similar exercises undertaken in earlier times, we have identified what we think are the key factors underpinning the economic results:

- Where there is a requirement to retain non-pregnant females to maintain breeder numbers, improving herd reproduction efficiency will likely improve herd output as each additional pregnant breeder effectively replaces a non-pregnant breeder held to maintain breeder numbers.
- This improvement is on the basis that it is (genetic) fertility and not herd nutrition that limits the capacity of cows to reconceive on a more regular basis.
- The assumption that the herd mortality rate will not change with the change in the calving percentage is also very important to the results. Increasing the number of females that calve closer to an annual basis in this environment is considered likely to increase the herd mortality rate. Each manager will need to incorporate an assessment of whether the mortality rate will change in any analysis undertaken.
- Once herd performance is at a level where culling all non-pregnant breeders is possible, measureable economic benefits appear unlikely for even the most beneficial implementation scenarios. Any improvement in reproduction efficiency above this level of performance causes replacement of cull cows with cull heifers or vice versa due to the limit placed on total grazing pressure applied by the AE cap.
- The point where all non-pregnant cows can be culled in any breeding herd can be determined by expected mortality rates, the final age of culling breeders, and the optimal age to cull replacement heifers and the optimum age to sell steers. The optimum culling or selling age can also be determined by the relative sale values of the various classes of sale stock and these relativities can change over time.
- Another complicating factor is that many northern breeding herds have their performance limited by the level of phosphorus deficiency of the land types grazed and appropriately managing the phosphorus status of the herd may lift herd performance to a level where finding benefits for also genetically improving fertility may become very challenging.

The starting herd performance and the herd structure that optimises returns both need identification prior to modelling the value of genetically changing the conception rates of the breeding component of the herd. The modelling process also needs to be able to accurately follow the changes in herd structure and herd numbers that occur as a change in herd management is implemented. This is critically important where change takes decades to flow through a herd. Failure to incorporate the aspects of time and risk in the analysis of the costs and benefits of changing the performance of a breeding herd in northern Australia largely negates the value of the analysis.

The components required to make a genetic selection program effective on an extensive cattle station in northern Australia have complex interactions and may require a complete rethinking of the current herd management strategy and property operations. Furthermore, the potential benefits should ideally be examined on a property by property basis to account for the property-specific details in terms of location, operational size, land capability, climate, herd performance and existing management practices.

6.4.4 Investing to reduce foetal/calf loss in breeding females

This scenario identified the value of an investment to reduce foetal/calf loss in breeding females.

The Cash Cow project (McGowan et al 2014) identified median values of calf loss of 16.4% in heifers, 9.5% in first lactation cows and an overall rate of 12.9% for the Northern Forest. (Table 173) These parameters were previously applied in the construction of the Katherine "without change" herd model.

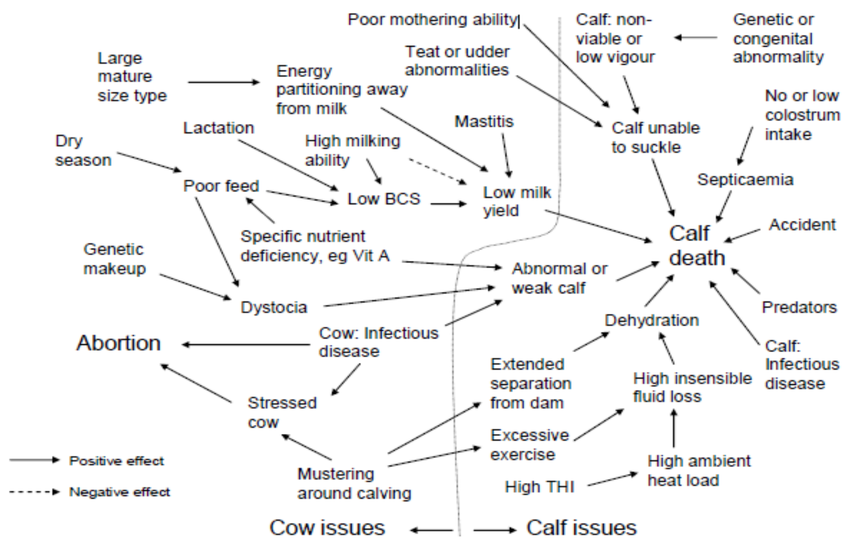
Table 173 Median reproduction performance for Northern Forest data (McGowan et al 2014)

Parameter	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%

Calf loss percentages were determined in the Cash Cow 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. By definition, foetal and calf loss as it was derived excludes cow mortality.

The Cash Cow project developed a possible causal pathway for calf loss. (Figure 29)

Figure 29 Possible causal pathway for foetal and calf loss in northern Australia (McGowan et al 2014)



If a relatively high value for loss in any age class of females was identified on any property, the property manager would need to work their way through the factors likely to be affect calf/foetal loss in their herd and identify the causal pathway. From there an analysis based on the identified cause and effect pathways can proceed.

The wide range of possible agents and combinations of agents identified by the Cash Cow project together with a lack of other research data indicating a "typical" cause and effect relationship for our beef enterprise limits the identification of appropriate examples for analysis and requires us to rephrase the question in two ways.

Firstly, the question is rephrased to look at what level expenditure could be incurred on a per head per annum basis to resolve a calf loss problem. The first question is - “if $5, $10 or $15 was spent per retained breeder and calf/foetal loss was reduced by half, what would be the return on the funds spent?”

The Cash Cow project (McGowan et al 2014) identified that additional capital costs could be required to address the problem of calf/foetal calf loss. They found “Increasing levels of cattle control that enable higher levels of husbandry—such as effective fencing, good paddock design, appropriate segregation, training of cattle, and selection for temperament—may substantially reduce foetal/calf loss”.

Therefore, secondly, the question can also be “what amount of upfront capital could be spent to reduce calf mortality by 50% on this property?”

To answer these questions the Breedcowplus base herd model was modified by:

- Halving the calf loss values for all classes of breeding females.
- Calculating the new weaning percentage and the new percentage sales after mating.

Comparison with the starting Katherine herd model reveals that the weaners as a percentage of cows mated changes from 54.67% to 58.86%, the average number of weaner’s increases by 100 per annum, the number of cull heifers and cows sold increases by about 53 per annum and the number of steers sold increases by about 43 on average.

Table 174 Comparison of base herd outputs with one that has 50% lower foetal and calf loss

Parameter	starting herd	50% lower calf loss
Total adult equivalents	7400	7400
Total cattle carried	9523	9577
Weaner heifers retained	1291	1341
Total breeders mated	4722	4557
Total breeders mated & kept	4109	3966
Total calves weaned	2582	2682
Weaners/total cows mated	54.67%	58.86%
Weaners/cows mated and kept	62.83%	67.64%
Overall breeder deaths	6.00%	6.00%
Female sales/total sales %	44.22%	44.70%
Total cows and heifers sold	894	947
Maximum cow culling age	11	11
Heifer joining age	2	2
Weaner heifer sale & spay	0.00%	0.00%
One year old heifer sales %	0.00%	0.00%
Two year old heifer sales %	33.59%	40.44%
Total steers & bullocks sold	1128	1171
Max bullock turnoff age	3	3

The implementation process reflects the expectation that a one-year (minimum) lag between expenditure and receipt of benefits would be expected for any strategy aimed at improving calf/foetal loss. The treatment cost allowance includes the cost of any treatment plus any additional labour required to undertake the treatment. Only females older than 12 months old and retained in the breeder herd for the full year receive the treatment. The effective economic life of additional capital invested was taken to be 30 years with no residual value.

Table 175 records the results of the investment analyses at cost levels of $5, $10 and $15 per female treated plus upfront capital expenditure of $100,000, $300,000, $600,000 and $800,000.

Table 175 Investment analysis of a 50% reduction in calf loss

Expenditure	Period of analysis (years)	NPV @ 5%	Annualised return	Peak deficit	Years to peak deficit	Payback period (years)
$5 /head	30	$593,451	$38,605	-$26,575	1	1
$10 /head	30	$192,142	$12,449	-$87,635	4	9
$15 /head	30	-$209,167	-$13,607	-$560,431	never	never
$100,000 capital	30	$899,522	$58,515	-$100,000	1	2
$200,000 capital	30	$804,284	$52,320	-$200,000	1	5
$400,000 capital	30	$613,806	$39,929	-$400,000	1	9
$800,000 capital	30	$232,855	$15,148	-$800,000	1	19

It would appear that no more than $10 per head should be spent on reducing calf/foetal loss by 50% in all retained breeding females if a return on the funds invested was being sought. Spending more than $10 per treated female or gaining a reduction in calf loss of less than 50% in the classes of female treated would make any investment unlikely to produce a positive return on funds invested.

For this size of herd and enterprise, expenditure of up to $400,000 as upfront capital expenditure with no additional ongoing expenses appears worthwhile of further consideration on the basis that calf foetal / calf loss is reduced by at least 50% across the entire breeding herd. At this level of investment the impact on enterprise profit could still be significant but lesser expenditure would be more favoured if it could achieve the same result.

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 - only by the current level of herd productivity and the change in herd productivity realised 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 Table 175.

6.4.5 Investing to reduce mortality rates in breeding females

Henderson et al (2012) worked with 36 properties across nine regions of northern Australia to estimate total female, breeder and male death rates. They could not clearly identify cause and effect relationships between particular strategies and changes in mortality rates. For this reason this scenario looked firstly at what level of expenditure could be incurred on a per head per annum basis to reduce female mortality rates and then considered the amount of upfront capital that could be spent to reduce female mortality rates.

The first question is - "if $5, $10 or $15 was spent per head and mortality rates in females were reduced by 50% (one half), what would be the return on the funds spent?" The second question is - "what amount of upfront capital ($50,000, $200,000 or $500,000) could be spent to reduce female mortality rates by one half?"

Each question was considered by reducing all female mortality rates in the starting herd Breedcowplus model for the Katherine region by one half. Table 176 shows a herd that has its mortality rate in females reduced will sell, on average, 181 more cull cows and surplus heifers. Note that because steer mortality rates are unchanged and the female herd structure is changed, about 181 fewer steers were sold on average if only the mortality rate of the female component of the herd is changed.

Table 176 Comparison of base herd and herd with female mortality rates reduced by 50%

Parameter	starting herd	50% Reduction in female mortality
Total adult equivalents	7400	7400
Total cattle carried	9523	9419
Weaner heifers retained	1291	1271
Total breeders mated	4722	4624
Total breeders mated & kept	4109	4050
Total calves weaned	2582	2543
Weaners/total cows mated	54.67%	54.99%
Weaners/cows mated and kept	62.83%	62.78%
Overall breeder deaths	6.00%	3.00%
Female sales/total sales %	44.22%	49.18%
Total cows and heifers sold	894	1075
Maximum cow culling age	11	11
Heifer joining age	2	2
Weaner heifer sale & spay	0.00%	0.00%
One year old heifer sales %	0.00%	0.00%
Two year old heifer sales %	33.59%	48.18%
Total steers & bullocks sold	1128	1111
Max bullock turnoff age	3	3

The model incorporated a one-year lag between the expenditure and the change in mortality rates. Comparison of the herd with reduced mortality rates in females with the base herd provided the following investment values.

Table 177 Investment analysis of a 50% reduction in female mortality rates

Expenditure	Period of analysis (years)	NPV @ 5%	Annualised return	Peak deficit	Years to peak deficit	Payback period (years)

$5 per head	30	$979,326	$63,707	-$33,020	1	1
$10 per head	30	$477,289	$31,048	-$66,040	1	2
$20 per head	30	-$526,785	-$34,268	-$1,445,342	never	never
$100,000 capital	30	$1,386,125	$90,169	-$100,000	1	1
$500,000 capital	30	$1,005,173	$65,388	-$500,000	1	7
$750,000 capital	30	$767,078	$49,899	-$750,000	1	11
$1,250,000 capital	30	$290,887	$18,923	-$1,250,000	1	never

Table 177 indicates that the annual profit of the enterprise will be improved by about $31,000 per annum if $10 per female expenditure reduced the female mortality rate by 50%. Expenditure of up to about $1,000,000 could be invested to improve enterprise profit if female mortality rates were reduced by 50% for the next three decades.

There appears to be a need to think about responses to mortality rates in females from a different perspective. The role of capital investment in achieving higher levels of cattle control may need more detailed consideration – possibly more consideration than strategies incurring an ongoing cost to achieve the same outcome. This aligns with the findings of the Breeder mortality project (Henderson et al 2012).

6.5 Strategies that target the steer component of the herd

6.5.1 Steer sale age

The price premiums provided by the live export market for light steers to Indonesia and the uncertainty surrounding their future price level often leads to the sale of lightweight steers at the end of the first wet season after weaning. Holding these lighter steers back from sale until they were heavier is often seen as risky as there has been a chance of missing the premium price. Pasture quality during the dry season in this region limits the capacity of the lighter steers to gain significant weight after the end of May and a higher sale weight can only be gained by holding steers through another wet season in many cases.

The starting herd model for Katherine holds steers for two wet seasons after weaning before selling the first cohort. To test whether selling the steers lighter (first cohort after one wet season) or heavier (after three wets), the Breedcowplus model was reconfigured with the various ages of sale and the breeder herd rebalanced.

Table 178 shows the sale weights for the starting Katherine herd when the first cohort of steers were sold after the second wet season in May with the second cohort sold 12 months later. The cut-off sale weight was 320 kg in the starting herd. Eighty one percent of steers were expected to be above the minimum paddock weight at the first sale point.

Table 178 Splitsal analysis for selling steers in the starting herd model

Average (mean) liveweight of group	355	Cutoff weight for first sale age	320
Standard deviation (SD) of weights	40	% of group above cutoff weight	81%
		Average weight of heavier group	368
In a "normal" distribution, 95% of individual weights			
will range from 277 kg to 433 kg		Average weight of lighter group	298
		Expected gain if sold at next age	90
		Weight of lighter group by next age	388

Table 179 shows the sale weights when the first cohort of steers were sold after the first wet season in May with the second cohort sold 12 months later. The cut-off sale weight was reduced from 320 kg in the starting herd to 270 kg in this example. Only 46% of steers were expected to be above the minimum paddock weight at the first sale point.

Table 179 Splitsal analysis for selling steers 12 months younger

Average (mean) liveweight of group	265	Cutoff weight for first sale age	270
Standard deviation (SD) of weights	40	% of group above cutoff weight	46%
		Average weight of heavier group	300
In a "normal" distribution, 95%			
of individual weights will range from 187 kg to 343 kg		Average weight of lighter group	236
		Expected gain if sold at next age	90
		Weight of lighter group by next age	326

If all steers are sold in the 36 to 48 months age bracket, there is no need to split the mob into a lead and tail. The average sale weight when all steers were sold twelve months older was 445 kg in the paddock.

Table 180 shows the consequences for the herd structure and herd gross margin for selling the first cohort of steers twelve months earlier or twelve months later on average than indicated for the starting Katherine herd model. Each herd structure shows the change in sale age fully implemented.

Table 180 Steer sale age analysis – Katherine region

Parameter	starting herd	12m younger same price	12m younger -10c/kg	12m older same price	12 m older -10c /kg
Total adult equivalents	7400	7400	7400	7400	7400
Total cattle carried	9523	9355	9355	9541	9541
Weaner heifers retained	1291	1380	1380	1179	1179
Total breeders mated	4722	5049	5049	4313	4313
Total breeders mated & kept	4109	4394	4394	3753	3753
Total calves weaned	2582	2761	2761	2358	2358
Weaners/total cows mated	54.67%	54.67%	54.67%	54.67%	54.67%
Weaners/cows mated and kept	62.83%	62.83%	62.83%	62.83%	62.83%
Overall breeder deaths	6.00%	6.00%	6.00%	6.00%	6.00%
Female sales/total sales %	44.22%	43.23%	43.23%	45.47%	45.47%
Total cows and heifers sold	894	956	956	816	816
Maximum cow culling age	11	11	11	11	11
Heifer joining age	2	2	2	2	2
Two year old heifer sales %	33.59%	33.59%	33.59%	33.59%	33.59%
Total steers & bullocks sold	1128	1255	1255	979	979
Max bullock turnoff age	3	2	2	3	3
Average female price	$639.34	$639.34	$639.34	$639.34	$639.34
Average steer/bullock price	$811.11	$676.49	$647.59	$981.18	$940.17
Capital value of herd	$5,097,616	$5,010,244	$4,990,875	$5,280,669	$5,280,669
Imputed interest on herd value	$254,881	$250,512	$249,544	$264,033	$264,033
Net cattle sales	$1,486,140	$1,460,495	$1,424,211	$1,482,735	$1,442,583
Direct costs excluding bulls	$245,248	$246,425	$246,425	$240,097	$240,097
Bull replacement	$61,433	$65,692	$65,692	$56,106	$56,106
Gross margin for herd	$1,179,459	$1,148,379	$1,112,094	$1,186,531	$1,146,380
GM after imputed interest	$924,578	$897,866	$862,550	$922,498	$882,346
Difference to starting herd		-$26,712	-$62,028	-$2,080	-$42,232

Holding the steers an additional twelve months before sale and achieving the same average price as the starting herd would make the beef property no worse off. If the steers sold later received about 10 cents per kilogram liveweight less on average, the beef property would be about $42,000 per annum worse off (once the transition was completed). All of the older steers were sold in the same month in this example.

Selling the first cohort of steers after the first wet and receiving the same price would cost the beef property about $27,000 per annum in profit. Selling them younger and receiving 10 cents per kilogram liveweight less would cost the beef property about $62,000 per annum in profit. Selling the steers younger and gaining 10 cents per kilogram across only the lead cohort produces a herd gross margin about $9,000 per annum less than the starting herd structure (data not shown).

There are differences in the relative profitability for the age of sale options depending upon the long-term assumption re prices. It appears the starting strategy of selling the first cohort of steers after the second wet season was the more acceptable option but the perception of a large premium for lightweight steers could often see the first cohort sold after the first wet season.

6.5.2 Investing to reduce mortality rates in steers

The rate of mortality identified by Henderson et al (2014) for steers is higher in this region than the mortality rate identified for females. We have not followed this finding in the starting herd and have applied the same mortality rate of 6% to steers and females. This scenario investigated the value of reducing the retained mortality rates by 50%. Actual strategies where a cause and effect relationship can be established will need to be developed for the circumstances of each herd.

Table 181 indicates that reducing the mortality rate in steers by 50% and not changing the mortality rate of the female herd causes the number of weaners produced to fall by 20 even though the weaning rate was maintained. Slightly fewer females were sold (7) but the number of steers sold increased by 70. This was because the herd structure changed to accommodate the greater number of steers surviving and reduced the breeder herd component proportionally to maintain the same overall grazing pressure (7400 AE).

Table 181 Comparison of base herd and herd with steer mortality rates reduced by 50%

Parameter	starting herd	50% less steer mortality
Total adult equivalents	7400	7400
Total cattle carried	9523	9503
Weaner heifers retained	1291	1281
Total breeders mated	4722	4686
Total breeders mated & kept	4109	4078
Total calves weaned	2582	2562
Weaners/total cows mated	54.67%	54.67%
Weaners/cows mated and kept	62.83%	62.83%
Overall breeder deaths	6.00%	6.00%
Female sales/total sales %	44.22%	42.54%
Total cows and heifers sold	894	887
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year old heifer sales %	33.59%	33.59%
Total steers & bullocks sold	1128	1198
Max bullock turnoff age	3	3

Analysis was undertaken to show the impact of different levels of expenditure ($50,000, $100,000 and $500,000 capital or $5, $10 and $20 per steer) on the property returns to achieve a 50% reduction in steer mortality. All steers including weaner steers kept or sold during the year were treated. Benefits were lagged by one year.

Table 182 Investment analysis of a 50% reduction in steer mortality rates

Expenditure	Period of analysis (years)	NPV @ 5%	Annualised return	Peak deficit	Years to peak deficit	Payback period (years)
$5 per head	30	$471,420	$30,667	-$19,215	1	3
$10 per head	30	$168,885	$10,986	-$65,871	3	6
$20 per head	30	-$436,185	-$28,374	-$1,207,973	never	never
$50,000 capital	30	$726,337	$47,249	-$50,000	1	2
$100,000 capital	30	$678,717	$44,152	-$100,000	1	3
$500,000 capital	30	$297,765	$19,370	-$503,493	2	14

It appears profitable to concentrate on investing in capital structures that effectively reduce steer mortality rates. Very low cost annual treatments applied to all steers kept or sold during the year also seem to be a reasonable investment.

6.5.3 Pasture development – augmentation with stylos

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 (palatable, productive and perennial) 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 over sown stylo, could 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 (Cooksley 2003).

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 $6,000/km for the fencing and $5,000 for an additional water point) and then aerially sown to stylo after being burnt. Table 183 indicates the steps required to establish the stylo pasture. It is acknowledged that the 4-year development phase before reaching full production is subject to suitable rainfall seasons.

The development process relies upon finding a suitable area that has soil phosphorus greater than 4 ppm, fencing that area and then aerially sowing the stylo after a late season burn.

Local knowledge relevant to the region identifies a need to stock the stylo at least fully, possibly slightly more, in the first wet season after sowing. Stylo is sown in December in most years with steers put into the paddock immediately after sowing to reduce grass competition with the young stylo. Verano, in particular, is not readily grazed early on but grazing pressure has to be removed by mid-March, before cattle begin eating the young pasture.

Steers were not reintroduced into the stylo pasture until after the following wet season (at the end of June).

Table 183 Stylosanthes pasture development steps (calendar year)

Pasture	Year 1	Year 2	Year 3	Year 4
Stylo	Remove steers in May, burn late season and seed.	Add steers January, remove stock in March. Grass only weight gain and stocking rate	Add stock in July. Graze at the grass-stocking rate with stylo monthly gains.	Remove steers in May and replace with weaners in June. Stock at stylo rate and weight gains

The costs of sowing the pasture include the cost of the seed and the cost of flying the seed onto the burnt paddock. (Table 184)

Table 184 Stylosanthes direct development costs

Planting Costs	Rate of application	number of applications	Cost per hectare
Stylo seed*	2 kg	1	$40.00
Flying on legume	1	1	$12.50
Total direct development costs			$52.50

*Need to ensure high germination seed is used – at least 35%.

The introduction of Stylosanthes (stylo) pastures for steers to the Katherine property was initially assessed by developing a 1000 ha paddock to run steers from weaning to sale with steers sold either at the normal time in May or at a later time in September. Another scenario considered the development of area of stylo pasture sufficient to run all steers produced by the breeder herd from weaning to their point of sale.

In both scenarios, stylos were sown to land types typical to the region assessed as being P-deficient (ca. 4 ppm in the top 100 mm of soil). Several levels of pasture utilisation were examined.

A range of assumptions were made for pasture composition, diet quality and animal liveweight response with reference to published data from trial sites both inside and 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.)

The land type for the paddock to be developed (Sturt land system – Pettit 2011) has an average annual biomass production of 1800 kg DM/ha in its current condition. The recommended utilisation rate for annual pasture biomass is 15% for this land type (Pettit 2011). Predicted biomass production for a stylo and grass pasture on this land type was 1800 kg DM/ha average annual grass biomass production plus an additional 1000 kg DM/ha average annual stylo biomass production**.** The assumed utilisation rates of grass pasture and stylo averaged across the annual cycle resulted in about a 36% average stylo content in diet selected across the year. This was considered broadly representative for these pasture systems (Coates 1996; J. Rolfe, pers. comm.)

Once fully established, steers will graze the stylo pasture from weaning. Table 185 shows the expected post weaning, monthly weight gains for the pasture with and without stylo. Steers grazing both pastures also received a wet season P supplement.

Table 185 Steer growth rates for steers grazing stylo grass pastures and steers grazing perennial grass

Month	Grass + wet P kg/d	Grass + wet P kg / head	Grass + stylo +wet P kg/d	Grass + stylo + wet P kg / head
Jan	0.7	21.7	0.7	21.7
Feb	0.7	19.6	0.7	19.6
Mar	0.7	21.7	0.7	21.7
Apr	0.6	18.0	0.6	18.0
May	0.6	18.6	0.55	17.1
Jun	0	0.0	0.473	14.2
Jul	0	0.0	0.2	6.2
Aug	0	0.0	0.2	6.2

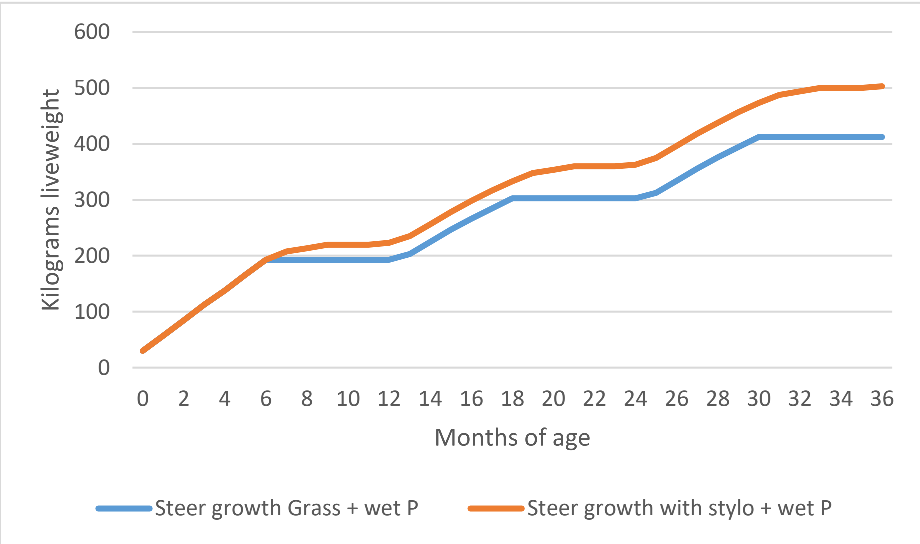
Sep	0	0.0	0	0.0
Oct	0	0.0	0	0.0
Nov	0	0.0	0.1	3.0
Dec	0.3355	10.4	0.4	12.4
Average /Total	0.30	110.00	0.38	140.0

Note: the steers in the starting Katherine herd scenario only received a dry season N+P supplement. As feeding supplements to steers in the dry season alone has minimal impact on annual weight gains of steers (Tim Schatz pers. comm.), this scenario feeds adequate wet season P to optimize steer growth on both the native grass pasture and the stylo grass pasture. The benefit of feeding wet season P to steers from weaning has previously been estimated at 30 kg per annum (see P analysis). The stylo pasture was expected to add an extra 30 kilograms per head per annum to steer weight gain.

The comparison is therefore between steers grazing native pastures from weaning, receiving a wet season P supplement and gaining 110 kg per head per annum and the same paddock sown to stylo, stocked with weaners, receiving a wet season P supplement and gaining 140 kg per head per annum.

Figure 30 shows the expected weight gain for steers grazed on native pastures augmented with stylo and wet season P for 30 months from weaning. This is compared to the expected growth of steers on native pastures with a wet season P supplement for the same period.

Figure 30 Growth paths for steers



The maintenance of weight gains later into the year on stylo pastures together with better weight gain overall may allow a different timing of sale. Two sale months (May or September) were tested to target the relative change in stock sale price that can regularly occur across the seasons in northern Australia.

Figure 31 indicates the average intra-annual variation in the light export steer price for Darwin. For the period 01/01/2006 to 31/12/2018, average monthly prices varied by up to 40 c/kg liveweight greater than prices that prevail, on average, in May or June. Although the variation in prices within 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. September and a price premium of 20 cents per kilogram liveweight was chosen in this example to fit in with second round mustering activities and to match the expected end of the potential annual weight gain on stylo. Access to the steers during the wet season (on the example property) limits the potential to chase potentially higher prices in other months.

Figure 31 Monthly price variation for light export steers from January 2006 to December 2018 (Source 'MLA - Australia Live Export cattle prices, monthly)

The benefit of the price premium was assessed by selling all steers either off stylo at 18 months of age (May) or at 22 months of age (mid-September).

The 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'.

A mean annual biomass production of 1,800 kg DM/ha with 15% 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 1,800 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 15% or 30%, depending on scenario, resulting in a 36% average stylo content (respectively) in diet selected across the year. The steers grazing stylo-grass pastures were expected to grow about 27% faster per annum (+30 kg liveweight) than steers grazing the same pasture without stylo.

Table 186 shows the calculation of the area required to run a steer from 6 months old until sale off either perennial grass or, alternatively, off an established stylo grass pasture in the same paddock at a 20% utilisation rate. The higher dry matter production and the higher digestibility of the stylo grass pasture underpin the difference.

Table 186 Grazing area calculation for perennial grass and stylo infused pasture post weaning to sale

Parameter	Perennial grass 15% utilisation, May sale	Perennial grass + stylo 15% utilisation, May sale	Perennial grass + stylo 15% utilisation, September sale
Number of steers	1	1	1

Days on forage	365	365	488
Average weight gain (kg/d)	0.3005	0.3837	0.3421
Average age (yrs.)	1.0	1.0	1.2
Average weight (kg)	248	263	276
Average DMD of diet (%)	49.5	54	54
DM Consumption per head per day (QuikIntake)	8.3	8	8
Kgs consumed by livestock (kg dry matter)	3,030	2,920	3,904
% of dry matter consumption as grass	100%	50%	50%
%of dry matter consumption as stylo	0%	50%	50%
Kgs grass consumed by livestock (kg dry matter)	3,030	1460	1952
Kgs stylo consumed by livestock (kg dry matter)	0	1460	1952
Expected utilisation grass	15%	15%	15%
Expected utilisation stylo	0%	15%	15%
Expected annual grass production	1,800	1800	1800
Expected annual stylo production		1000	1000
Expected annual paddock dry matter (kg /ha)	1,800	2,800	2,800
Total grass yield for grazing days	1,800	1,800	1,800
Total stylo yield for grazing days	0	1,000	1,000
Grass biomass available for consumption	270	270	361
Stylo biomass available for consumption	0	150	201
Hectares required to meet steer demand for 1 year	11.22	6.95	6.95
Acres required to meet steer demand for 1 year	27.71	17.17	17.17
Area (adjusted for number of days > 365) Hectares	11.22	6.95	9.30

Table 187 shows the area required to run the tail of the steers on perennial grass until sale. All the steers on the stylo pasture were sold at the end of first 12 months grazing.

Table 187 Grazing area calculation for perennial grass from the sale of first cohort to sale of the tail in May

Parameter	Perennial grass 15% utilisation, May sale
Number of steers	1
Days on forage	365
Avg weight gain (kg/d)	0.3005
Avg age (yrs.)	2.0
Avg weight (kg)	335
Avg DMD of diet (%)	49.5
DM Consumption per head per day (QuikIntake)	10.4
Kgs consumed by livestock (kg dry matter)	3,796
% of dry matter consumption as grass	100%
%of dry matter consumption as stylo	0%
Kgs grass consumed by livestock (kg dry matter)	3,796
Kgs stylo consumed by livestock (kg dry matter)	0
Expected utilisation grass	15%
Expected utilisation stylo	0%
Expected annual grass production	1,800
Expected annual stylo production	0
Expected annual paddock dry matter (kg /ha)	1,800
Total grass yield for grazing days	1,800
Total stylo yield for grazing days	0
Grass biomass available for consumption	270
Stylo biomass available for consumption	0
Hectares required to meet steer demand for 1 year	14.06
Acres required to meet steer demand for 1 year	34.73
Area (adjusted for number of days > 365) Hectares	14.06

Table 188 shows the calculation of the area required to run a steer from 6 months old until sale in either May or September off an established stylo grass pasture at a 30% utilisation rate.

Table 188 Grazing area calculation for perennial grass and stylo infused pasture post weaning to sale

Parameter	Perennial grass + stylo 30% utilisation, May sale	Perennial grass + stylo 30% utilisation, September sale
Number of steers	1	1
Days on forage	365	488
Average weight gain (kg/d)	0.3837	0.3421
Average age (yrs.)	1.0	1.2
Average weight (kg)	263	276
Average DMD of diet (%)	54	54
DM Consumption per head per day (QuikIntake)	8	8
Kgs consumed by livestock (kg dry matter)	2,920	3,904
% of dry matter consumption as grass	50%	50%
%of dry matter consumption as stylo	50%	50%
Kgs grass consumed by livestock (kg dry matter)	1460	1952
Kgs stylo consumed by livestock (kg dry matter)	1460	1952
Expected utilisation grass	30%	30%
Expected utilisation stylo	30%	30%
Expected annual grass production	1800	1800
Expected annual stylo production	1000	1000
Expected annual paddock dry matter (kg /ha)	2,800	2,800
Total grass yield for grazing days	1,800	1,800
Total stylo yield for grazing days	1,000	1,000
Grass biomass available for consumption	540	722
Stylo biomass available for consumption	300	410
Hectares required to meet steer demand for 1 year	3.48	3.48
Acres required to meet steer demand for 1 year	8.59	8.59
Area (adjusted for number of days > 365) Hectares	3.48	4.65

Table 189 indicates the expected sale weights for steers grazing the native pasture and receiving a wet season P supplement. All steers are sold of the stylo in one cohort at their average paddock weight.

Table 189 Steer sale weights off native pasture calculated in Splitsal

Average (mean) liveweight of group			303			Cutoff weight for first sale age	320
Standard deviation (SD) of weights			40			% of group above cutoff weight	35%
						Average weight of heavier group	346
In a "normal" distribution,							
95% of individual weights will range from	225	kg to		381	kg	Average weight of lighter group	280
						Expected gain if sold at next age	110
						Weight of lighter group by next age	390

6.5.3.1 Paddock analysis (1000 hectares)

This component of the stylo analysis considers the development of a paddock and does not incorporate any impacts on herd structure or overall property stocking rate. The chosen paddock is a relatively small component of the property and the impact of ignoring those factors on the marginal returns will be minimal.

Prior to the stylo development, the paddock will have:

- a steer age structure and sale pattern the same as the steer age structure and sale pattern of the overall herd that receives an effective P supplement program,
- weaner steers (49) enter the paddock in May; one death is expected to the end of the year.

- yearling steers (48) from the previous weaning will be in the paddock, one steer died since weaning, and 17 of the 48 will be sold at 18 months old and 346 kg (paddock weight) as the weaners enter.
- 30 steers that are 30 months old (and 390 kg paddock weight) will also be sold as the weaners enter the paddock in May.

For a 1,000 ha paddock developed to stylo and grazed at a 15% utilisation rate:

- Steers will enter the paddock as weaners and will be all sold in one cohort after 12 months in the paddock (May sale) or after 16 months in the paddock (September sale).
  - May sale scenario - weaner steers (144) will enter the paddock in May and 136 are sold after 12 months on stylo at an average paddock weight of 333 kg.
  - September sale scenario – weaner steers (107) enter the paddock in May and held until September the following year when 101 are sold at 360 kg liveweight in the paddock.

For a 1,000 ha paddock that has been developed to stylo and has a 30% utilisation rate: 287 weaner steers will enter the paddock in the May sale scenario and 214 weaner steers will enter the paddock in the September sale scenario. Paddock weights at sale are the same as the 15% utilisation of stylo scenario.

Table 190 shows the results for each component of the paddock of stylo analysis. Holding steers on stylo pastures until later in the year to gain a price premium of 20 c/kg live and selling the steers at a heavier weight improves economic performance. Increasing the utilisation rate of stylo-grass pastures from 15% to 30% substantially increased economic performance. A low rate of utilisation together with a May sale point makes the paddock development uneconomic.

Table 190 - Marginal returns for investing in 1000 ha of stylo-grass pastures for steers from weaning to sale

Factor	Stylo-grass pastures 15% utilisation, May sale	Stylo-grass pastures 15% utilisation, +20 cents/ kg live September sale	Stylo-grass pastures 30% utilisation, May sale	Stylo-grass pastures 30% utilisation, +20 cents per kg live September sale
Period of analysis (years)	30	30	30	30
Interest rate for NPV	5.00%	5.00%	5.00%	5.00%
Marginal NPV	$17,066	$122,482	$254,814	$473,571
Annualised marginal NPV (extra profit/year)	$1,110	$7,968	$16,576	$30,806
Peak deficit (with interest)	-$116,654	-$97,717	-$189,841	-$149,218
Year of peak deficit	4	4	4	4
Payback period (years)	n/a	11	11	7
Marginal IRR	2.71%	13.75%	14.27%	27.28%

The implementation of stylo pastures for steers in a 1,000-hectare paddock resulted in a substantial peak deficit for the enterprise of at least -$100,000 in all scenarios and a payback period of 7 years minimum.

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 Sturt Plateau conditions over 30 years.

6.5.3.2 Property development scenario

The paddock development scenario was expanded from the initial 1000 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 plant 1,000 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.

At the property level, prior to the development of the stylo pastures, the steers grazing native pastures with adequate wet season P supplementation need access to about 14,272 ha for 365 days from weaning to the sale of the first cohort (1,272 steers @ 11.22 hectares per steer). The top 35% were removed at this time and sold at an average liveweight of 346 kg in the paddock. The residual 778 steers then grazed 11,087 ha for 365 days (1 steer to 14.08 hectares) until they were sold in the following May with a paddock weight of 390 kg. The total area of native pasture allocated to the steers was ca. 25,360 ha.

The analysis applied the 30% utilisation and September sale parameters when developing the stylo pasture over time. The comparison was with a breeder herd that received an effective P supplementation program.

If the yearling steers were grazed on stylo-grass pastures utilized at 30% until a September sale this would free up 19,448 ha of land to be grazed by other classes of stock in the breeding herd. If 14.87 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 by about 1300 AE 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 191 shows the change in herd structure enabled by the 30% utilisation of stylo grass-pastures.

Table 191 – Property development scenario - breeder herd components without the stylo development and with the stylo development at 30% utilisation rate, once fully established and with a sale target of mid-September

Breeder herd components	Native grass pasture (P supplemented base herd)	Stylo-grass pasture for steers – 30% utilisation; sale in mid-September
Total cows and heifers mated	4,619	5,485
Calves weaned	2,543	3,020
Weaner steers	3,826	1,510

A stylo-grass paddock of 7,017 ha was required to provide an appropriate balance between an expanded breeder herd and suitably sized stylo-grass paddock for the steers. About 1,510 weaner steers are expected to enter the stylo paddocks in May each year with 1,465 steers sold off stylo at 22 months of age.

In the property development scenario, from Year 1 of the analysis, 1,000 ha of stylo was over-sown (and costed) each year for 8 years. However, to account for annual rainfall variation causing less successful establishment in some years, only 7,100 ha of the area sown was assumed to establish effectively. This area was sufficient to run 1,510 weaner steers until sale in mid-September each year. The stylo paddocks were assumed to require part fencing (at $4,000/km) plus a water tank, poly pipe and trough costing $7,500 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.

The grazing of the stylo paddock during the development phase followed the same pattern as described in the paddock development scenario.

Table 192 shows the marginal return to developing a sufficient area of the property to stylos over time (8 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 will all conspire to reduce the marginal return on capital. (Note: the IRR could not be calculated in this case due to the extended development phase)

Table 192 - Marginal returns for investing in sufficient stylo-grass pasture to run all steers (May sale; 20% utilisation)

Factor	**Stylo-grass pastures 30% utilisation September sale Property level development**
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	$2,282,461
Annualised marginal NPV (extra profit/year)	$148,477
Peak deficit (with interest)	-$506,055
Year of peak deficit	8
Payback period (years)	11
Marginal IRR	n/c

The annualised marginal NPV of $148,477 for stylo-grass pastures 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 significant peak deficit for the enterprise of -$506,055 (due to the extended period of development) and a payback period of 11 years. The extended payback period arises due to the full implementation of the stylo development taking more than a decade.

6.5.4 Feeding the tail of the steer weaners with concentrates

The tail of the weaner steers often requires an additional wet season to achieve sale weights. This scenario separates the weaner's post weaning and feeds the tail an energy supplement in the paddock. The goal of the feeding exercise was to get the steer weaner tail up to the same weight as the lead of the weaner group going into their first wet season and then sell the entire age cohort at the end of the first wet post weaning.

Figure 32 shows the expected growth path of the lead of the steer weaners and the tail of the steer weaners with and without the supplement. The green line shows the hoped for impact of the supplement on the growth path of the lighter steers.

Figure 32 Expected growth path for steer lead (80%) and steer tail (20%)

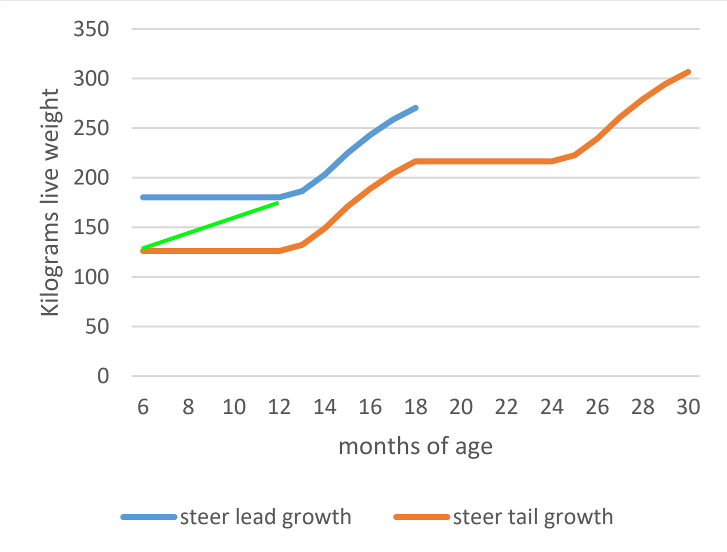


Table 193 shows the expected weight split of the weaner steers. The lead (80%) will have an average weight of about 180 kilograms going into the wet while the tail (20%) will have an average weight of about 126 kilograms if they were not fed.

Table 193 Weaner steer weight distribution

Average (mean) liveweight of group	170	Cut off weight for first sale age	144
Standard deviation (SD) of weights	30	% of group above cut off weight	81%
		Average weight of heavier group	180
Note: In a "normal" distribution, 95% of individual weights will range from 111 kg to 229 kg		Average weight of lighter group	126
		Expected gain if sold at next age	0
		Weight of lighter group by next age	126

Table 194 shows the calculation of feeding costs and includes the cost of the fodder and labour to feed the supplement. The supplement is a commercially available grain based supplement expected to cost about $440 per ton landed on the property. An additional $5000 in capital was required for feeding out troughs. The expected life of the feeding troughs is 30 years.

Table 194 Calculation of steer weaner tail supplement feeding costs

Feeding cost calculator	Item
Number to be fed	224
Current weight in the paddock (kg live)	126
Expected daily gain (kg/day)	0.36

Expected average number of days on feed (days)	150
Expected exit weight (kg liveweight)	180
Feed Requirement (% of liveweight consumed per day as dry matter)	1.60
% dry matter in feed	100%
Total Feed Requirement (kg per head as fed)	367
Kilograms /head per day consumption	2.45
Estimate of total feed required (tons)	82.25
Cost of Feed as fed ($/tonne including mixing costs and transport to property)	$440.00
Feed costs in $/head	$161.57
Total cost of fodder	**$36,191**
Cost of feeding out	
Fed out (times per week)	3.50
Number of times fed	75
Wages and fuel for 1 feeding out	$35
Total cost of feeding the fodder	$2,625
Total cost of the supplement and the feeding out	**$38,816**
Cost per head fed	**$173.29**

Table 195 indicates the marginal or extra returns generated by feeding the weaner steer tail with and energy ration so they are sold with the lead of the steers. Feeding and selling the tail of the weaner steers a year earlier significantly reduces the profitability of the property. Part of this is due to the marginal profitability associated with the feeding exercise and part of it is due to the expansion in the breeding herd facilitated by the feeding exercise having a substantially lower gross margin than the steer component of the herd (the weaner tail from 18 to 30 months of age) that it replaces.

Table 195 Marginal returns for feeding the steer tail with an energy supplement – long term prices

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$479,121
Annualised return (profit/year for analysis period)	-$31,168
Period of analysis (years)	30
Peak deficit (with interest)	-$1,344,287
Payback year	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

The long-term steer prices applied in the analysis may be reducing the profitability of the feeding exercise. This was tested by increasing the average steer sale price for all steers to $3.00 per kg (lead) and $2.90 per kg (tail). Table 196 indicates that the steer feeding exercise is still expected to significantly reduce profit, even if high prices for steers are continued into the near future.

Table 196 Marginal returns for feeding the steer tail with an energy supplement – higher long term prices

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	-$307,844
Annualised return (profit/year for analysis period)	-$20,026
Period of analysis (years)	30
Peak deficit (with interest)	-$867,521
Payback year	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

6.5.5 Feeding the tail of the steers on the floodplains

Another option that may improve profit is to send the tail of the steers to the flood plains on agistment after they have been through their second wet season. Perusal of the growth path of the steer tail shows they will average 280 kilograms liveweight in May when they are about 15-18 months old. Table 197 indicates the expected additional costs of sending the steers to the flood plains for about six months on agistment.

Table 197 additional costs associated with agisting the steer tail on the flood plains

Extra trucking	36	head/deck	300	kms	$1.95	per km	$16.25
Fly tags							$5.00
Agistment cost ($/week /head)	$3.00	$/week					
Start date	1/05/2019	End Date	31/10/2019	26.14	weeks	cost	$78.43
				183	days		
Total cost							$99.68

The expectation is that the steers will average 0.60 kilograms per head per day weight gain if they stay on the flood plains until late in the year, with a significant portion of the gain likely to occur towards the end of the period. On this basis, the final weight of the tail of the steers will be 390 kilograms in the paddock and they will sell at the same long-term average price as the rest of the steers.

The removal of the tail of steers in May when they are 12-15 months of age allows an adjustment to the breeding herd structure so that an expanded breeding herd now grazes the area of pasture formally grazed by the steer tail. Table 198 indicates the change in herd structure expected over time.

Table 198 Herd structure with and without the steer tail sent to the flood plains

	Base herd +P	**Base herd with the steer tail sent to the flood plain**
Total cows and heifers mated	4619	4943
Calves weaned	2543	2722
Weaner steers	1272	1361

Table 199 indicates the marginal or extra return generated by agisting the steer tail on the flood plains so they are sold in the same year as the lead of the steers. Agisting and selling the tail of the steers a year earlier improves the profitability of the property without incurring measurable deficit.

Table 199 Marginal returns for agisting the steer tail on the flood plains

Factor	**Value**
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$915,695
Annualised return (profit/year for analysis period)	$59,567
Period of analysis (years)	30
Peak deficit (with interest)	n/a
Payback year	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

6.5.5.1 Feeding the lead and tail of the steers on the floodplains

The improvement in profit arising from sending the tail of the steers to the flood plains encourages consideration of sending the full complement of steers. In this scenario, all steers were sent on agistment in May, including the lead 35% that would normally be sold at that time.

The extra costs of feeding the heavier steers was slightly more per head due to a higher cost per head for transport. It was assumed that they would gain the same weight per day on average. They will again stay on the flood plains for the same period to achieve the full benefit of the grazing strategy.

In this case, the breeder herd was not adjusted as the lead of the steers go to the flood plains at the normal time they would have been sold. They were sold off the flood plains at about 413 kilograms live in the paddock.

Table 200 indicates the marginal or extra return generated by agisting all of the steers on the flood plain. Agisting all of the steers will potentially significantly improve the profitability of the property without incurring a measurable deficit. There is little data to confirm the parameters applied in this scenario and further investigation would be required before applying this strategy.

Table 200 Marginal returns for agisting the steer tail on the flood plains

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$1,783,765
Annualised return (profit/year for analysis period)	$116,036
Period of analysis (years)	30
Peak deficit (with interest)	n/a
Payback year	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

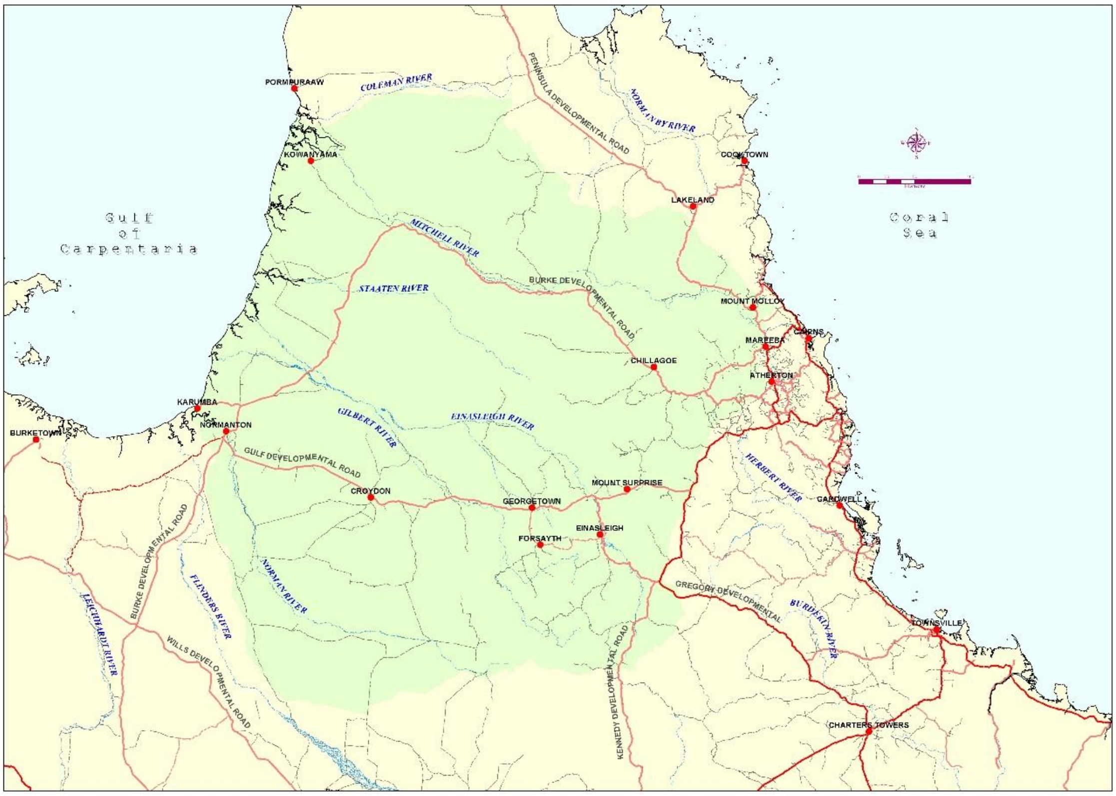
7 Region 3: the northern Gulf region

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^{o} and 19^{o} south latitude and 141^{o} and 145^{o} east longitude.

Around 60% of the region is contained in the Northern Gulf Plains bioregion (Sattler and Williams 1999) while the remaining 40% is contained in the Northern Einasleigh Uplands bioregion.

There are approximately 196 grazing businesses covering an area of about 12.4 million hectares. These businesses rely on (principally) native pastures to turn off about 260,000 head of cattle per year with a value of approximately $180 million. A range of markets is targeted from live export, the store market, the US grinding beef trade and the transfer of weaners to growing and fattening areas in southern and central Queensland. Total herd size in the Northern Gulf Region is approximately 800,000 head of which about 520,000 are breeders and heifers 12 months and older. (ABS 2018a,b)

Figure 33 approximate location of the northern gulf region



Rolfe et al (2016) studied 18 beef enterprises encompassing 39 properties. These covered an area of 1.104 million hectares and represented 29 families, employing 56 full time equivalents (FTE).

They found:

- Producers in the region target the live export, slaughter and United States grinding beef markets. Many owners transport weaners to southern growing and fattening properties endeavouring to lift animal performance. High female mortalities, poor reproductive performance and low annual liveweight gains are commonly recorded. (Henderson et al. 2013; McGowan et al. 2014).

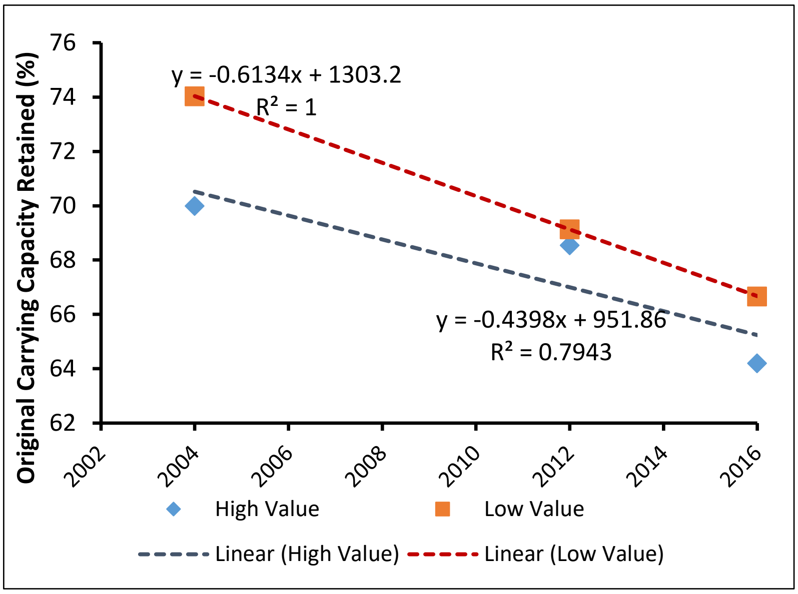
- Most enterprises operate a breeding enterprise in the Gulf and one or more finishing properties located outside the region. On average, each family had assets of $9.4 million and liabilities of $3 million. Low profitability and significant liabilities led to most enterprises negotiating interest-only repayment terms with their respective lenders. At the time of analysis, only two were making regular principal and interest payments.
- Only six had a systematic wet season spelling program in place over the previous 5 years. Average cattle numbers, as calculated across the previous 5 years, exceeded long-term 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.
- Weaning rates were less than or equal to 50% for eight enterprises and ranged from 50% to 60% on three. The remaining seven had weaning rates >60%. Low annual liveweight gain (70–90 kg per 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 per head. Four enterprises use pasture improvement on their Gulf breeding operations and/or finishing properties located outside the region to increase annual liveweight performance (120–150 kg per 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 enterprises. Missing females and/or high mortalities constrain sales income and female replacement. The female sales were weak (<40%) for six of the enterprises studied. Marginal female sales (40–44%) were recorded for eight whereas female sales were strong (≥45%) for four. The lowest female sales (34%) and the highest (48%) indicate female losses (mortalities and missing) range from 3% to 9%.
- Producers running extensive beef production systems face a complex mix of biophysical, productivity, family and financial challenges. It is inherently difficult for each family to manage such large scale (~38,000 hectares) and diverse grazing landscapes in a variable climate. Inadequate fencing and water infrastructure constrains rotational wet season spelling to 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.

7.1 The aim – sustainable and resilient production

A major constraint on beef production in the northern Gulf is declining land condition. We start by looking at declining land condition and what may be done about it. The aim is to have 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 region suggests that land condition has declined over recent decades with a prediction that it will continue to decline. Since 2004, the proportion of original carrying capacity retained has declined from 72% to 66%. This is in line with a similar decline in land condition. Continuing the trend suggest that 50% of original carrying capacity will be lost by 2046. (Shaw et al 2016)

Figure 34. Change in proportion of original carrying capacity retained at the 3 assessment times for high grazing value land types (grazing value >5) and low value land types (grazing value ≤ 5) (Shaw et al 2016)



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.

There can be no fixed recipes for halting the decline in land condition; rather there is a need to:

- understand the current position and outlook for a property with its current management strategy
- test and predict the value of available change to improve the resilience of the property
- monitor the impact of change as it occurs
- adjust management accordingly

There is also a need to assess the impact of change on the property and not just parts of the property. Focusing on one part of the property or paddock may allow problems to be isolated and solutions to be looked for however sight must never be lost of the whole property. That is the level where the costs and benefits of management change are accurately assessed.

7.2 A "typical" northern gulf beef property

As identified, the first step is to appreciate the current position and outlook for the property with its current management strategy. To assist understanding of this process, a beef enterprise was constructed to allow various scenarios for change to be considered. The property is located entirely within the northern Gulf region.

The case-study 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. 2016a; 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 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 case study herd (Table 201; 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 201 – Initial reproduction parameters and mortality rates for the base, case-study 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 202.

Table 202 – Average herd structure for the base, case-study enterprise

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*

AE, adult equivalent. A 2.25 year old, 450 kg steer at maintenance.
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 estimated to be ca. 86 kg/head and 82 kg/head for heifers. Figure 35 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 35 Estimated steer and heifer growth paths – opening land condition

The growth path shown in Figure 35 is the median/average growth path and doesn't show variability between years.   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 203).

Table 203 - Splitsal analysis of expected steer liveweight distribution for the base, case-study 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 36 and Figure 37 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 significant (up to 70%) increase in the prices paid compared to the average of the previous years. Abattoirs

Figure 36 - Cattle prices over time for slaughter cattle in north Queensland

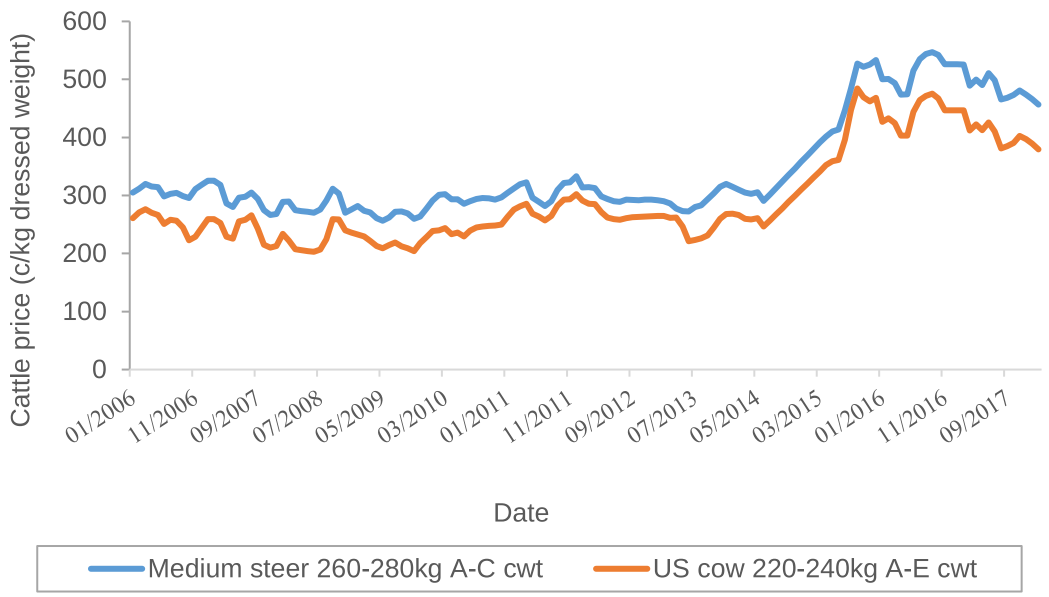
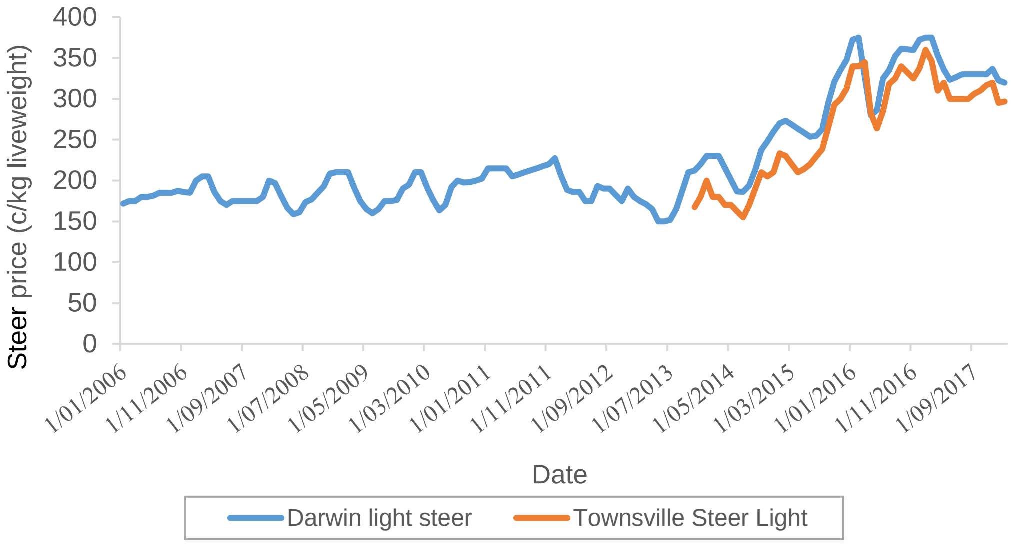


Figure 37 indicates that live export steers in Townsville have received lower prices on average than those exported from Darwin. For the period 2014 to end 2017, the same weight range of steers were, on average, 30 c/kg liveweight lower in Townsville than Darwin.

Figure 37 - 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 204). 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.

Table 204 – Cattle prices for live export cattle at Darwin and Townsville and for slaughter cattle in North Queensland markets (c/kg liveweight equivalent)

Parameter	Darwin live export		Townsville live export		North Queensland slaughter markets	
	Light heifer 260-350 kg	Light steer 260-350 kg	Light steer 260-350 kg	Medium steer 260-280 kg dressed weight	Heavy steer 300-400 kg dressed weight	US cow 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.

The price data was applied in the herd model with selling costs to calculate the net price per head of stock sold (Table 205).

Table 205 - Sale prices, selling costs, gross and net prices applied in the analysis for the Northern Gulf case-study enterprise

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 202 to produce the herd gross margin shown in Table 206.

Table 206 - Herd gross margin for the base, case-study enterprise

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	*$117,687*	*$47.07*

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

7.3 The impact of declining land condition on herd productivity

Continuing the current herd management strategy and stocking rate is expected to cause land condition to decline from the current 65% of the original carrying capacity to 60%, 55% and 50% over the next three decades (0.5% decrease in carrying capacity per year; Rolfe *et al.* 2016*a*; Shaw et al. 2017). (Table 216)

Table 207 - Predicted decline in carrying capacity over time

Year	% carrying capacity retained
2018	65%
2027	60%
2037	55%
2047	50%

The predicted result of the continued, but gradual fall in land condition is that by year 30 the same number of breeders will be held but herd performance will have fallen. Specifically:

- Steer growth rates will fall from about 86 kg per head per annum post weaning to about 82 kg per head per annum. Heifers will grow at a rate 5% slower than steers in each scenario.
- Weaners from all cows mated will fall from 47.35% to 46.92%
- Mortality rates will increase, on average, by 33% across all classes of stock from 7.5% to 10%.
- Average cull cow sale weights will fall by 10% from 430 kg to 390 kg
- The reduction in reproductive performance will cause the proportion of Pregnancy Tested Empty (PTE) 2-3 year old heifers sold to fall from 50% to 10%.
- The proportion of mature PTE breeders culled annually will be maintained at 5%.
- All prices of livestock will be maintained on a cents per kilo basis except it will take longer for steers and heifers to make sale weights.

Table 208 Predicted reproduction parameters and mortality rates at year 30 with a continued decline in land condition

Cattle age start year	**Weaners**	**1**	**2**	**3**	**4**	**8**
Cattle age end year	**1**	**2**	**3**	**4**	**8**	**13**
Expected conception rate for age group (%)	na	0	65	23	60	55
Expected calf loss from conception to weaning (%)	na	0	16.4	9.5	11.8	13.7
Proportion of empties (PTE) sold (%)	na	0	10	5	5	5
Female death rate	10.5	10.5	10.5	10.5	10.5	10.5
Male death rate	10.5	10.5	10.5	10.5	10.5	

Note: the figures for conception rate are modified from data reported for the region in the Cash Cow final report. Calf loss estimates are maintained at the median of the Cash Cow Northern Forest region. Table 209 shows the expected steer sale weights at the end of the 30 year period as calculated in Splitsal.

The major change to occur over the 30 year period is a gradual increase in the average rate of mortality. This is expected to be shown as occasional spikes related to extended dry seasons or a failed wet season. The average reproduction efficiency of the herd changes very little over the period as a majority of breeders have every second year off to recover from the stress of calving. Growth rates and sale weights decline as lad condition declines.

Table 209 shows the expected steer sale weights at the end of the 30-year period as calculated in Splitsal.

Table 209 Steer sale weights for the lead and tail of the herd at 50% land condition at year 30

Average (mean) liveweight of group	324	Kg	Cut off weight for first sale age (kg)	320
Standard deviation (SD) of weights	50	Kg	% of group above cut off weight	53%
In a "normal" distribution, 95% of			Average weight of heavier group (kg)	362
individual weights will range from			Average weight of lighter group (kg)	282
226 kg to	422	kg	Expected gain if sold at next age (kg)	82
			Weight of lighter group by next age (kg)	364

7.3.1 A snapshot of a possible future

Table 210 provides a snapshot of the herd performance at the beginning and at the end of the 30-year period if land condition was allowed to continue to decline and animal performance per head was reduced by the amount predicted.

Table 210 - A comparison of herd performance at 65% land condition and 50% land condition

Parameter	**Start year 65% carrying capacity**	**End 30 years 50% carrying capacity**	**Difference**
Total adult equivalents	2,500	2,410	-90
Total cattle carried	3,270	3,289	19
Weaner heifers retained	391	388	-3
Total breeders mated	1,651	1,653	2
Total breeders mated and kept	1,565	1,653	88
Total calves weaned	782	776	-6
Weaners/total cows mated	47.35%	46.92%	-0.43%
Overall breeder deaths	7.68%	10.50%	2.82%
Female sales/total sales %	39.78%	32.44%	-7.34%
Total cows and heifers sold	214	142	-72
Maximum cow culling age	11	11	0
Heifer joining age	2	2	0
Two year old heifer sales %	25.54%	6.75%	-18.79%
Total steers & bullocks sold	324	295	-29
Maximum bullock turnoff age	3	3	0
Average female price	$578.24	$563.36	-$14.88
Average steer/bullock price	$728.59	$563.36	-$165.23
Capital value of herd	$1,755,051	$1,723,133	-$31,918
Imputed interest on herd value	$87,753	$86,157	-$1,596
Net cattle sales	$360,332	$293,081	-$67,251
Direct costs excluding bulls	$100,191	$99,974	-$217
Bull replacement	$54,701	$54,752	$51
Herd gross margin	$205,439	$138,355	-$67,084
Herd gross margin less interest	*$117,687*	*$52,198*	*-$65,489*

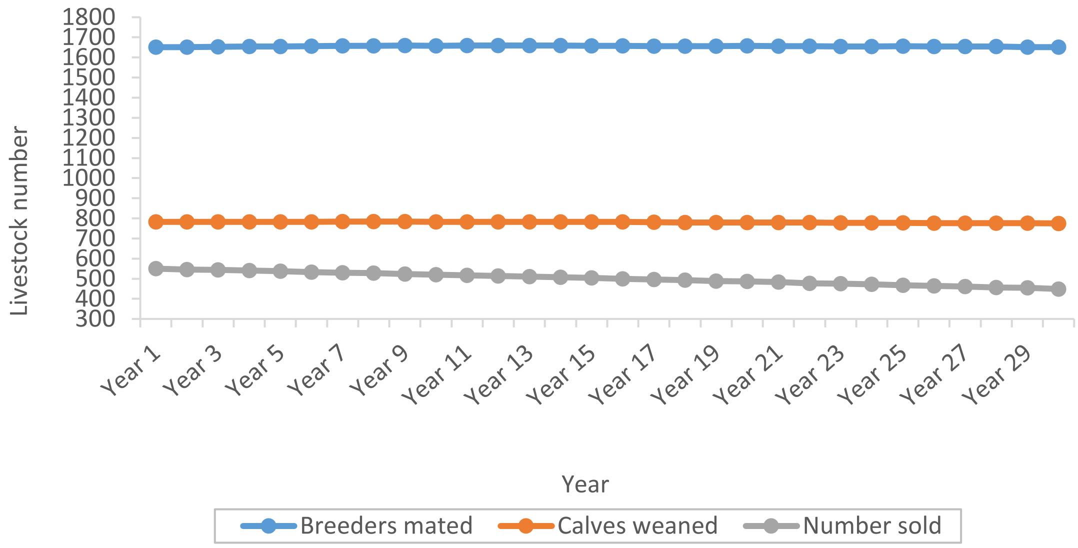
Although the number of cows mated, the total cattle carried and the prices per kilo are similar, the reduction in animal and herd performance attributable to declining land condition will reduce the expected herd gross margin by more than 50% by the end of the third decade. Note also that the relatively small change in herd parameters causes the percentage of females sold each year to reduce to about 32% on average. This is similar to the bottom level of herd performance recorded in the survey data provided by Rolfe et al (2016).

7.3.2 The impact on output

Figure 38 shows the change in livestock numbers over time. We show 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 large variation about the trend line.

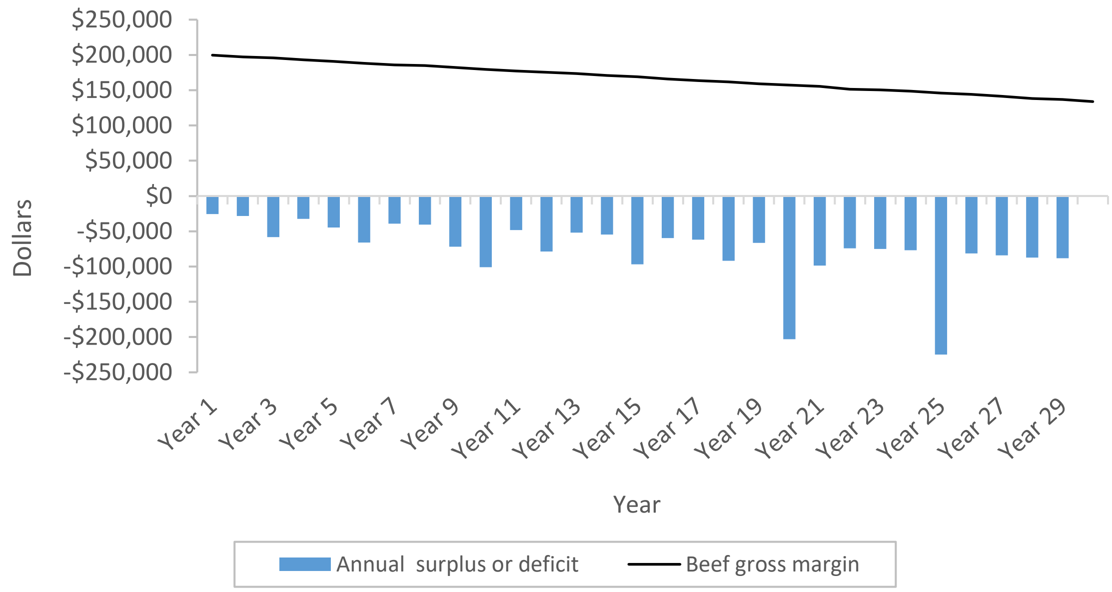
The end result of the continuing decline in land condition is a smaller number of calves being produced by the same number of breeders. The relatively higher mortality rates also causes a larger reduction in livestock sales over time.

Figure 38 - Livestock numbers and sales over time



The falling herd performance leads to a similar downwards trend in cash flow and beef gross margin. The blips in the graph correspond with the replacement of a number of significant plant items.

Figure 39 - Gross margin and annual surplus over time



7.3.3 The impact of declining pasture condition on closing assets

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 equity currently held if land value increased at 3% per annum above the rate of inflation over the 30 year period. This rate of increase in land value is similar to that achieved over the last 30 years.

Table 211 Impact on closing asset value of declining land condition

Parameter	Opening @ 65% land condition	Closing at 3%* annual increase in land value and 50% land 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%

** Rate of annual increase in land value in real terms*

Note: this scenario does not include any consideration of the opening level of debt and the impact of that on closing equity. There is also no market evidence that land condition is linked to land value and hence land appreciates at the same rate in the analysis regardless of land condition. Some beef producers will continue to follow a course of action that causes land condition to continue to decline as, given the likely increase in real land value over time, this can be seen as a low risk course of action that generates a low *cost of production*.

7.4 Key strategies to build profit and drought resilience

The representative, base beef production system defined was used as to test strategies for their ability to improve the long term profitability and drought resilience of the Northern Gulf beef business. Initially, two key strategies: 1) improving land condition and 2) adequate wet season P supplementation, were phased in sequentially so that by 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.

7.4.1 Long-term carrying capacity and wet season spelling

One of the strategies recommended to restore land condition is to reduce grazing pressure to the assessed long-term carrying capacity to allow the regeneration of more palatable and productive species. This can be encouraged by the rotational spelling of paddocks for the majority of a wet season over an extended number of years.

Grazing research and bio-economic 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 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.

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.

The predicted result of the expected, but gradual, improvement in land condition is that a reduced number of breeders will be maintained for the first decade after the rapid reduction but animal performance per head will improve at an incremental rate over the first decade. The changes include:

- Total grazing pressure was reduced from 2500 AE to 1500 AE (a 40% reduction) in the first year and then maintained at 1500 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 per head per annum post weaning. Heifers will still grow at a rate 5% slower than steers.

- Weaners/all cows mated improved from 47.35% to 49.87% over the first decade and be maintained at 49.87% to the end of the 30 year period (Conception rates in older cows increase by 2.5%).
- Mortality rates 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 period.
- Cull cow sale weights will improve to be 5% heavier by the end of the first decade and maintain this weight from then on. (410 kg to 430 kg)
- The PTE first calf heifer cull rate was increased to 75%.
- All prices of livestock were maintained as per the previous scenario.
- Cull females, steers and heifers were sold in the same month but at heavier sale weights.
- The incremental improvement in individual animal performance leads to a gradual fall in numbers to the end of the first decade as the goal is to maintain the same level of grazing pressure for the period, not the same number of cattle (heavier cattle result in a greater AE rating per beast).
- Carrying capacity will improve from 1500 AE to 1813 AE gradually over the following two decades as land condition improves.
- It is also assumed that no additional capital expenditure will be required for paddock subdivision or new watering points to effectively implement the wet season spelling system.

Table 212 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 212 Reproduction parameters and mortality rates with improved land condition at year 10

Cattle age start year	**Weaners**	**1**	**2**	**3**	**4**	**8**
Cattle age end year	**1**	**2**	**3**	**4**	**8**	**13**
Expected conception rate for age group (%)	na	0	65	33	63	55
Expected calf loss from conception to weaning (%)	na	0	16.4	9.5	11.8	13.7
Proportion of empties (PTE) sold (%)	na	0	75	5	5	5
Female death rate	5	5	5	5	5	5
Male death rate	5	5	5	5	5	

After the first decade, growth and mortality rates plus reproduction efficiency do not change although the improvement in land condition allows the adult equivalents carried by the property to improve from 1500 AE to 1650 AE by the end of the third decade.

7.4.1.1 Another snapshot of a possible future

Although the number of cows mated and the total carried fall significantly with the reduction in numbers, the improvement in herd performance attributable to improving land condition over the three decades produces a better gross margin. (Table 213)

Table 213 - Predicted steady state herd performance due to the restoration of land condition

Parameter	End 30 years 50% land condition	End 30 years improved land condition
Total adult equivalents	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

Figure 40 indicates that neither the number of cows mated nor calves weaned returns to the level for the scenario where land condition was allowed to fall over the next 30 years.

Figure 40 - Livestock outputs over time for the land condition restoration scenario

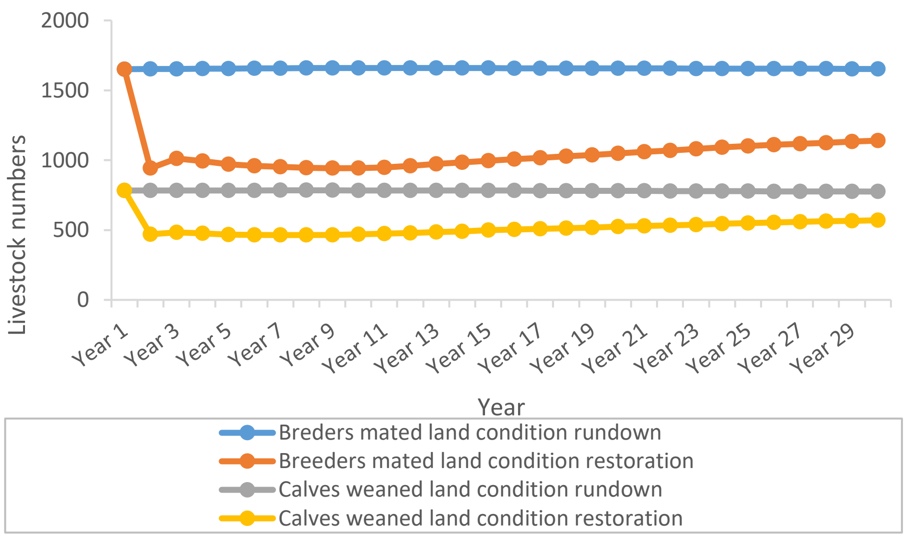
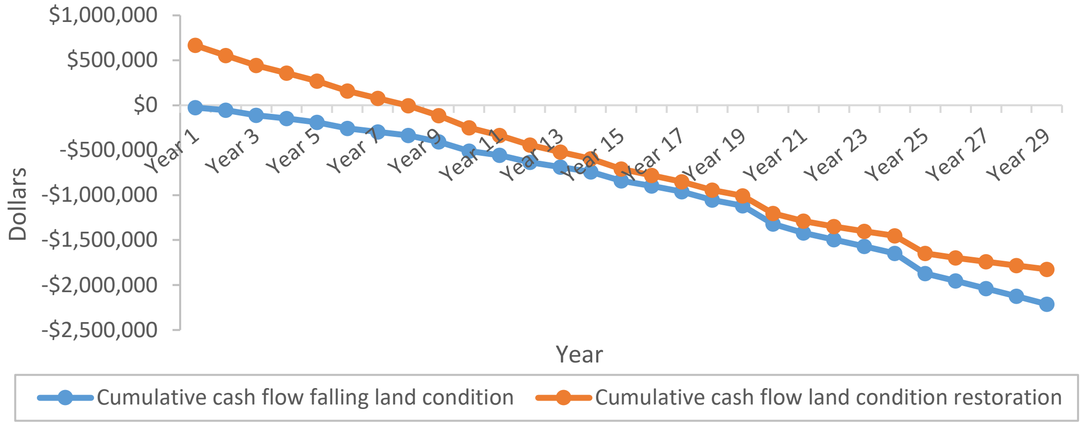


Figure 40 indicates that even though the number of cows mated and calves weaned do not achieve the expected levels of the scenario that allows land condition to decline, the cumulative cash flow of both the land condition restoration scenario and the land condition decline scenario end up in about the same place. Neither system is sufficiently profitable to pay the total costs of the property if livestock prices are maintained at the level of the longer-term average. The restoration scenario relies upon the initial release of capital associated with the herd reduction to carry the property through the early years of the transition.

That is, the sell down of the herd provides a cash buffer during the early years but the long term herd output associated with the improved land condition scenario is not capable of making the property significantly more profitable than the scenario that allows land condition to decline. Figure 41 shows the expected long-term cumulative cash flow for each scenario.

Figure 41 - Cumulative cash flow for the land condition scenarios



A beef producer who just reduces the stocking rate and then does nothing else except improve land condition is considered to have the same low chance of survival as the beef producer who allows land condition to continue its steady decline.

Table 214 indicates the marginal or extra returns generated by the land condition restoration scenario. The marginal NPV (extra profit per year over the analysis period) 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.

Table 214 Marginal returns for land condition restoration

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$232,624
Annualised return (profit/year for analysis period)	$15,133
Period of analysis (years)	30
Peak deficit (with interest)	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

Chasing an improvement in land condition through a rapid reduction in stock numbers seems unlikely to make the property more profitable or less exposed to risk. It appears the property needs to seek additional ways to improve its performance if it is to survive the challenges of producing beef in this environment.

7.4.2 Efficient feeding of a wet season Phosphorus (P) supplement

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 225). 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*).

The status levels and expected response to supplements for different levels of P deficiency are based on the categories of McCosker and Winks (1994) and the MLA phosphorus book (Jackson 2012) as adjusted by Dixon (2018 pers. comm.).

Table 215 Categories of P deficiency (soil Colwell P (mg/kg)) from 1994, 2012 'Phosphorus books' and R Dixon*

Category	1994 definition (Soil P in ppm)	2012 definition (Soil P in ppm)	Modified by R Dixon Category	(Soil P in ppm)
			Very severely deficient	</=2
Acute	<2	<4	Acute	2-3
Deficient	3-5	5	Deficient	4-5
Marginal	6-8	6-8	Marginal	6-8
Adequate	>8	-	Adequate	>8

**Note that 2012 definition of 'Acute' and 'Deficient' was modified due to limitations of the analytical method in detecting low soil P (<4). Rob Dixon was not satisfied with the 2012 definition applied in the Phosphorus book and we have used his suggested modified ranges for P deficiency in our analysis.*

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 business.

The herd currently runs on both acute and deficient soils and receives some wet season P supplement as proprietary blocks but this is considered an inadequate way of achieving the full benefits of an appropriate wet season P supplementation program.

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:

- Further increase the weaning rate from cows mated to 57.76%.
- Improve the pre-weaning growth rate in steers from 0.75 kg per day to 0.9 kg per day
- Improve the post weaning growth rate of steers from 86 kg per annum to 113 kg per annum
- Improve the pre-weaning growth rate in heifers from 0.71 kg per day to 0.86 kg per day
- Improve the post weaning growth rate in heifers from 82 kg per annum to 107 kg per annum.
- Cull cows to average 450 kilograms liveweight in the paddock (20kg heavier than the land condition improvement scenario)
- Mortality rates drop from 5% to 2.5%

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.

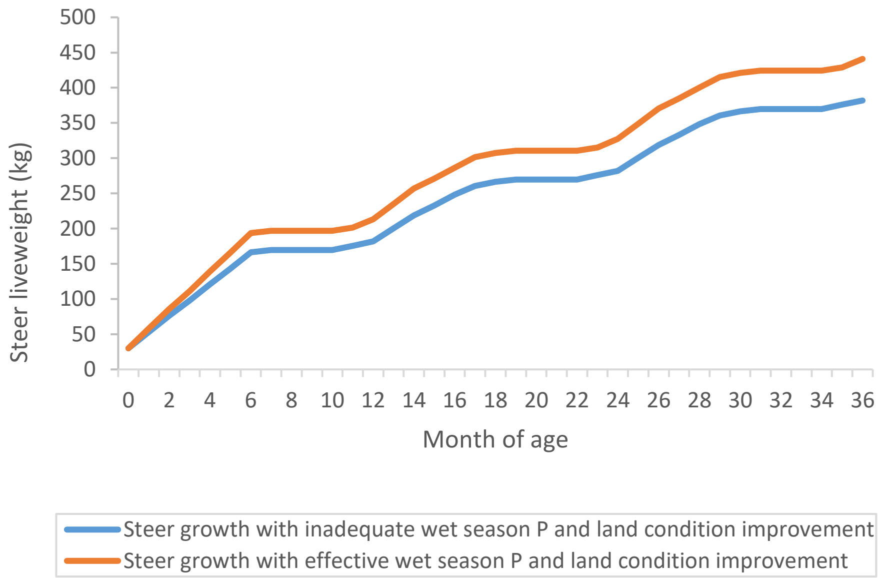
Annual supplement costs for the base herd (P blocks during the wet season) were weaners: $2.24/head, heifers and steers: $4.48/head, and breeding females: $6.72/head. The improved wet season P supplementation strategy involved a change from blocks to a loose mix in 'bulka' bags. The cost of feeding improved 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 216).

Table 216 - 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

Figure 42 shows the change in the expected growth rates of steers for the scenario where land condition is restored and inadequate wet season P is fed and the scenario where land condition is restored and effective wet season P is fed.

Figure 42 Steer growth with and without effective 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 217shows 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 217 Splitsal analysis of sale weights for steers receiving adequate wet season P and grazing land with improved condition

Average (mean) liveweight of group			415	kg	Cut off weight for first sale age	320
Standard deviation (SD) of weights			50	kg	% of group above cut off weight	97%
					Average weight of heavier group	418
95% of individual weights will range from	317	kg to	513	kg	Average weight of lighter group	300
					Expected gain if sold at next age	114
					Weight of lighter group by next age	414

Table 218 indicates the values for reproduction rates, calf loss and mortality expected for a breeder herd receiving adequate wet season P and running on country with improved land condition.

Table 218 Reproduction parameters and mortality rates for improved land condition and adequate wet season P

Cattle age start year Cattle age end year	Weaners 1	1 2	2 3	3 4	4 8	8 11*
Expected conception rate for age group (%)	na	0	78	45	70	65
Expected calf loss from conception to weaning (%)	na	0	16.4	9.5	11.8	13.7
Proportion of empties (PTE) sold (%)	na	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	

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

The adjustments made to the herd structure when adequate wet season P is fed (improved weaning rate and growth rate, lower mortality rate, earlier sale of some steers) lead to 60 more stock being sold at the same grazing pressure (1500 AE).

Table 219 Change in herd structure due to feeding adequate wet season P (1500 AE herd)

Parameter	Land condition restoration		Land condition restoration +P	
	Number held	Sold	Number held	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	1739	427

1.1.1.1 Another snapshot of a possible future

Although the number of cows mated and the total carried fall with the feeding of an adequate wet season P supplement to maintain the same grazing pressure, the improvement in herd performance attributable to improving land condition and effective wet season phosphorus supplementation together produces a significantly better gross margin than just improving land condition alone. (Table 220)

Table 220 Gross margin comparison of land restoration scenario and +P + land restoration scenario at the end of the first decade

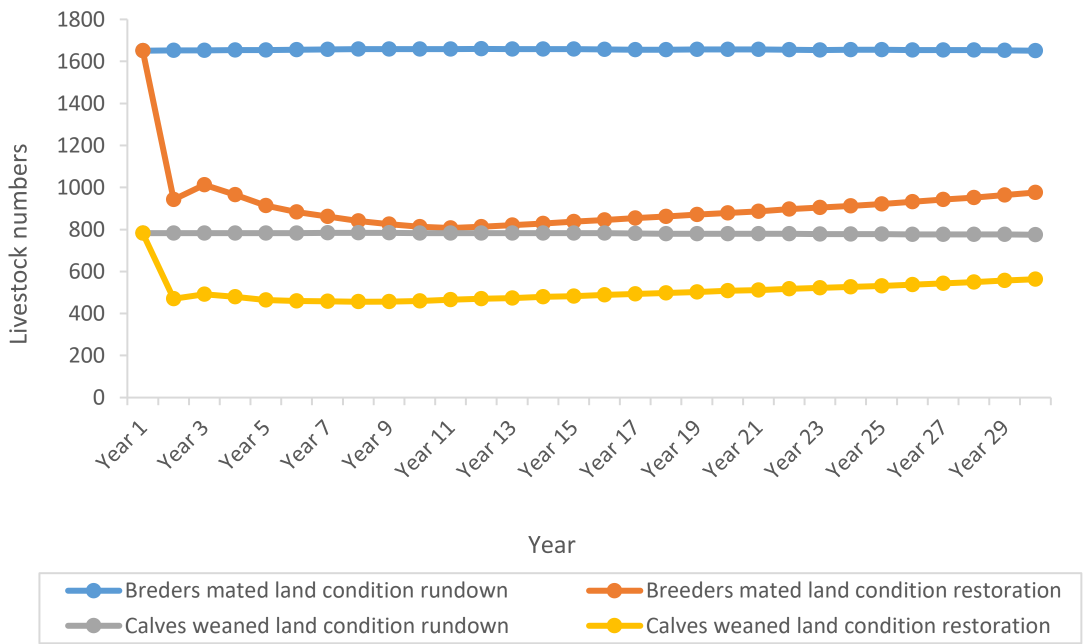
Parameter	Year 10 – land condition improvement	Year 10 – land condition improvement + adequate P	Difference
Total adult equivalents	1,500	1,500	0
Total cattle carried	1,907	1,739	-168
Weaner heifers retained	234	233	-1
Total breeders mated	938	805	-133
Total breeders mated and kept	874	751	-123
Total calves weaned	468	465	-3
Weaners/total cows mated	49.87%	57.76%	7.89%
Weaners/cows mated and kept	53.52%	61.91%	8.39%
Overall breeder deaths	5.00%	2.50%	-2.50%
Female sales/total sales %	44.73%	47.89%	3.16%
Total cows and heifers sold	167	202	35
Maximum cow culling age	11	11	0
Heifer joining age	2	2	0

Two year old heifer sales %	43.81%	60.55%	16.74%
Total steers & bullocks sold	207	220	13
Maximum bullock turnoff age	3	3	0
Average female price	$585.76	$671.27	$85.51
Average steer/bullock price	$728.64	$841.87	$113.23
Capital value of herd	$1,036,764	$996,850	-$39,914
Imputed interest on herd value	$51,838	$49,842	-$1,996
Net cattle sales	$248,670	$321,056	$72,386
Direct costs excluding bulls	$51,838	$63,107	$11,269
Bull replacement	$31,062	$26,309	-$4,753
Herd gross margin	$158,897	$231,640	$72,743
Herd gross margin less interest	*$107,058*	*$181,798*	*$74,740*

1.1.1.2 The impact on output over time

Figure 43 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..

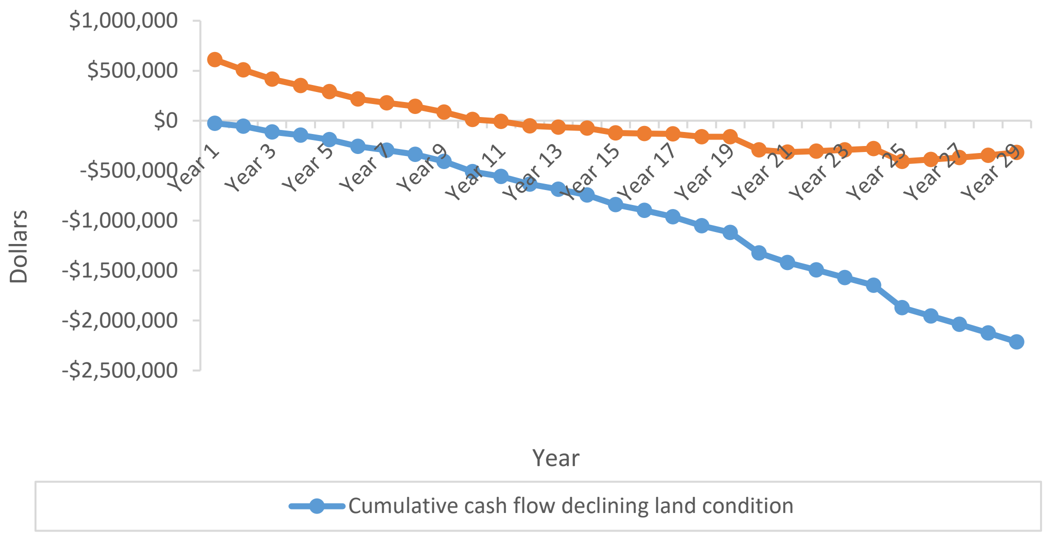
Figure 43 Herd output with wet season spelling and effective wet season P compared to land condition rundown



1.1.1.3 The impact on cash

The effective feeding of wet season P was considered likely to improve the net cash flow relative to the base scenario after the first decade.

Figure 44 Cumulative cash flow for falling land condition versus improving land condition and effective wet season P supplementation



The combination of a significant herd reduction, improvement in land condition over time and the effective feeding of wet season P supplements potentially improves the cumulative cash flow by more than $1.6 million over the three decades. Unfortunately, this appears insufficient to maintain the property.

Table 221 indicates the marginal or extra returns generated by the land condition restoration scenario combined with an effective wet season P program. Over the longer term, the profitability of the beef property was improved relative to the scenario where land condition was allowed to fall even though the underlying beef production system was still unlikely to profitable and sustainable with the management changes implemented so far.

That is, the values in Table 221 represent the difference between the scenario without P and land condition decline and the scenario with effective wet season P and land condition restoration, not that the land condition restoration and effective P supplement strategy together will make the property sufficiently profitable and resilient to consider it viable.

Table 221 Marginal returns for effective wet season P supplementation and land condition restoration

Factor	Value
Interest rate for NPV	5.00%
Marginal NPV of "Change" advantage	$918,720
Annualised return (profit/year for analysis period)	$59,764
Period of analysis (years)	30
Peak deficit (with interest)	0
Payback year	n/a
Payback period (years)	n/a
IRR of "Change" advantage	n/a

7.5 Building a 21st Century beef production system in the northern Gulf

The examples so far have looked at converting a property with falling land condition to one that does not have a continuing fall in land condition. The combination of an appropriate wet season P supplementation program with a herd reduction program followed by a wet season spelling regime suggests that the property is still unlikely to be both sustainable and profitable at long-term beef prices. The level of realized profit over the longer term depends largely on a hoped for continuing increase in real land value with the underlying beef production system expected to generate negative cash flows for some time.

A 21st Century beef production system needs to be sustainable, profitable and resilient and it can be seen that these conditions have not yet been met for our "typical" northern Gulf beef property. Further improvements to herd and property management need to be identified and tested to see whether they can improve the outlook.

Research and development activities in northern Australia over recent decades have identified a number of herd management strategies that, individually or in combination, may improve the performance of the beef property. The current beef production system (restored land condition and effective wet season P supplements) will be used as a base to test the value of changes to herd management suggested by research and development activities.

That is, all strategies from here on will be compared to a northern gulf property that runs 1500AE on the same area as previously, has an appropriate wet season phosphorus feeding program and achieves the levels of animal performance associated with this level of property management.

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 production system. 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. 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.

7.6 Strategies that target the steer component of the herd

Strategies that target steers will now be considered for the value they can add to the combined strategies of land condition restoration and the effective feeding of wet season phosphorus supplements.

7.6.1 Age of steer turnoff and market options

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.

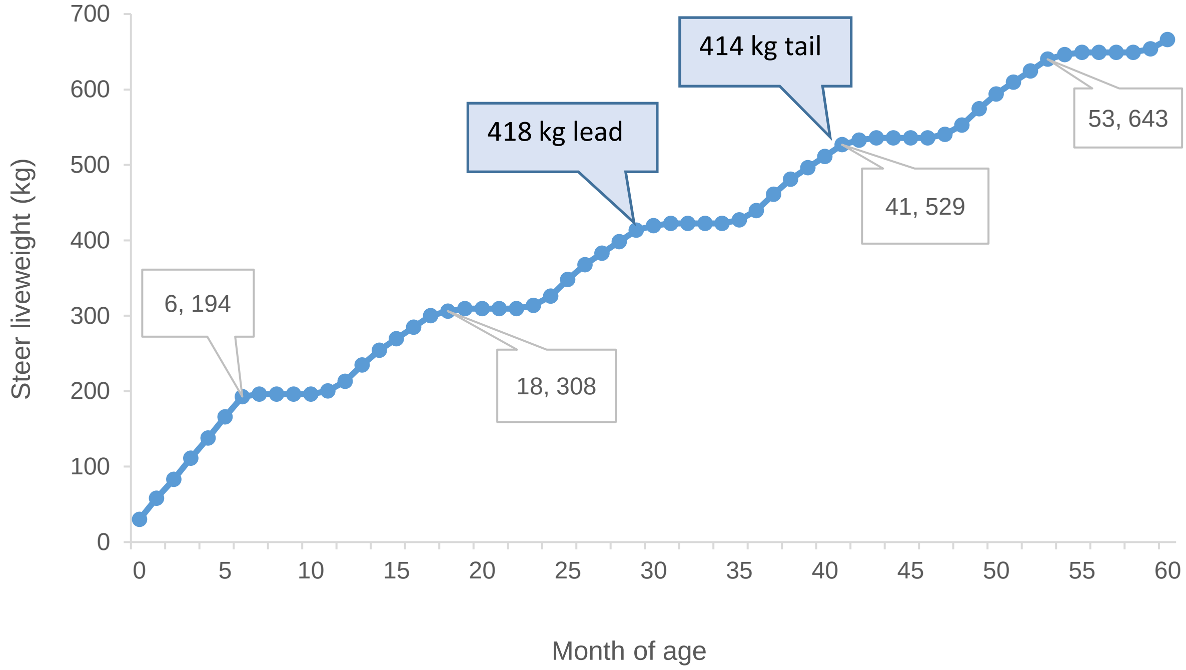
The effect of alternative steer sale ages was modelled by comparing the alternatives in a 'steady state' herd model consisting of 1,500 AE on the property and after 10 years of land condition improvement and adequate wet season P supplementation. That is, the expected herd performance at Year 10 (of 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 45 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.

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 and (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 45 – Northern Gulf steer weights with land condition improvement and adequate wet season P supplementation, showing alternative steer sale weights and ages



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 222 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 222 - 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 adult equivalents	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 yr old heifer sales %	60.55%	60.55%	60.55%	60.55%	60.55%
Total steers & 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	*$145,515*	*$161,319*	*$181,798*	*$196,216*	*$179,630*
Difference to base herd	-$36,283	-$20,479	$0	$14,418	-$2,167

Table 223 indicates the marginal or 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 223 - Marginal returns for moving to a steer sale age of 41 months compared to a 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

Factor	**Value**
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	$500,345
Annualised marginal NPV (extra profit/year)	$32,548
Peak deficit (with interest)	-$95,499
Year of peak deficit	2
Payback period (years)	8
Marginal IRR	23.65%

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

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.

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 224. The feed mix was expected to be about $363/t on property.

Table 224 – 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 225 indicates the calculation of depreciation, maintenance and labour costs for the fed steers.

Table 225 - 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

Table 226 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 227. 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 226 – 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 227 – 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 228. This presents the marginal or 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 228 - Marginal returns for feeding a molasses production mix to the tail of the steers compared to a base herd that is receiving adequate P supplementation and has benefited from 10 years of land condition improvement

Factor	Value
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	-$90,490
Annualised marginal NPV (extra profit/year)	-$5,886
Peak deficit (with interest)	-$252,532
Year of peak deficit	never
Payback period (years)	never
Marginal IRR	n/a

7.6.3 Stylo pastures on phosphorus deficient soils for steers

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 (palatable, productive and perennial) 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).

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 introduction of stylo pastures for steers was initially assessed by developing a 500 ha paddock. The paddock ran steers from weaning to sale in two age cohorts similar to the overall property and the steers were either sold at the normal time (May) or later in the season (September). Several levels of pasture utilisation were examined. In addition, a scenario was examined where sufficient stylo-grass pastures were established to run all weaner steers produced by the property until sale in May.

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 46 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 46 - Weekly average prices for heavy steers from January 1993 to December 2017 (Source 'MLA - Australia North Queensland OTH cattle indicators weekly')

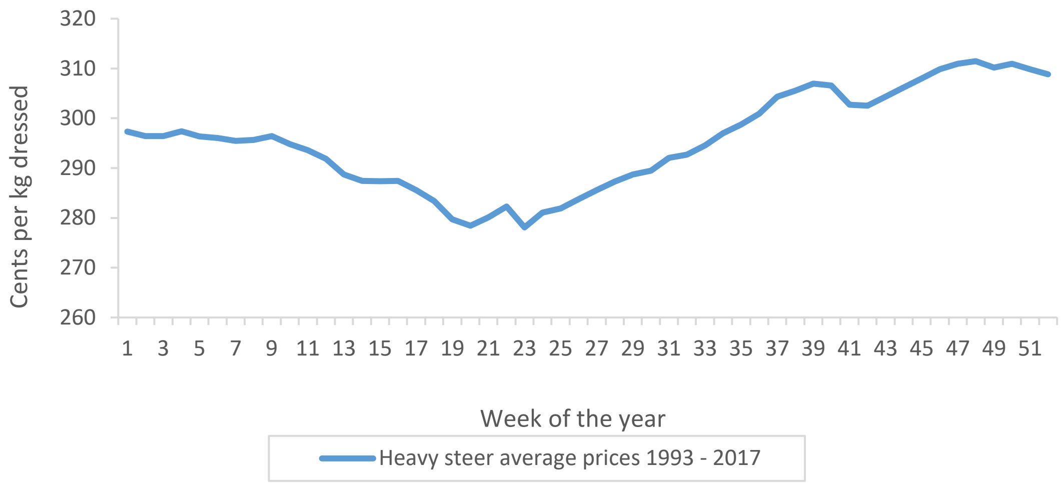


Table 229 indicates the seasonal variation in price for re-stocker steers, medium weight slaughter steers and US cow beef for the period of time originally applied, to decide sale prices to be used in this analysis. The prices shown are the average difference in price to the average price in May.

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 229 - 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 230 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 230 - 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 231). 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 231 - 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*

A lack of representative data for pasture composition, diet quality and legume composition, and animal liveweight response led to assumptions being 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 232). 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 233).

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 'adult equivalent' (AE). An adult equivalent was defined here 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 232 – 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 (adult equivalent); 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 233 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 233 – 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

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 234 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 234 – 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.

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 190). 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.

Table 235 - Marginal returns for investing in 500 ha of stylo-grass pastures for steers from weaning to sale

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
Interest rate for NPV	5.00%	5.00%	5.00%	5.00%
Marginal NPV	$78,097	$78,539	$265,951	$279,085
Annualised marginal NPV (extra profit/year)	$5,080	$5,109	$17,301	$18,155
Peak deficit (with interest)	-$66,402	-$60,930	-$92,731	-$81,070
Year of peak deficit	6	6	6	6
Payback period (years)	12	12	9	9
Marginal IRR	11.20%	11.91%	20.28%	22.16%

Table 236 shows the marginal 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 marginal return on capital.

Table 236 - Marginal 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.

Factor	**Stylo-grass pastures – 20% utilisation May sale Property level development**
Period of analysis (years)	30
Interest rate for NPV	5.00%

Marginal NPV	$476,713
Annualised marginal NPV (extra profit/year)	$31,011
Peak deficit (with interest)	-$270,595
Year of peak deficit	9
Payback period (years)	15
Marginal IRR	10.02%

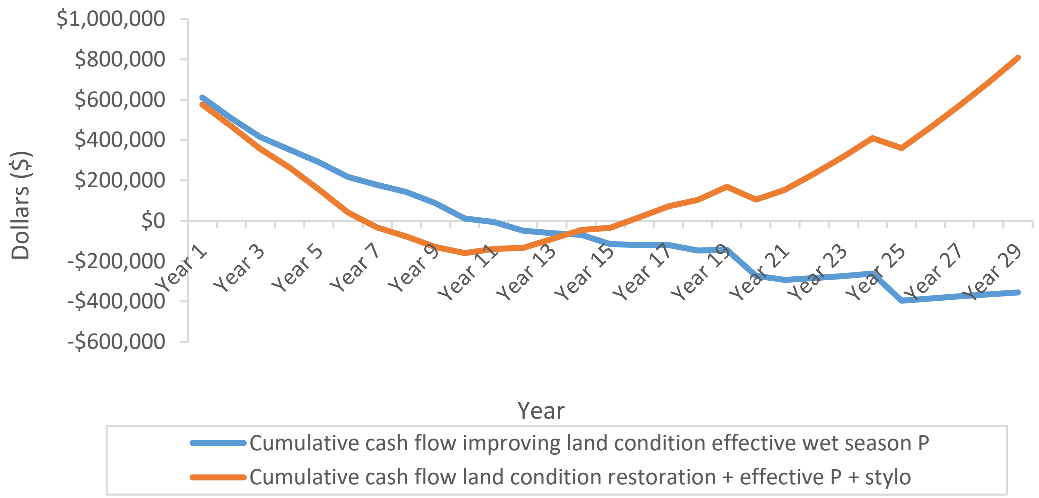
The annualised marginal NPV of $31,011 for stylo-grass pastures represents the average annual change in profit over 30 years resulting from the management strategy. The implementation of stylo pastures for steers resulted in a substantial peak deficit for the enterprise of -$270,595 and a substantial 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 business 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; Bowen and Chudleigh 2018*b*) but with much greater IRR's, e.g.: 33.51% and 25.8% 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 47 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 47 - Cumulative cash flow for the property with stylo planted for steers (20% utilisation, May sale of steers)



7.6.4 Stylo pastures and phosphorus fertiliser

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 production systems. 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 237, 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 237 - 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 25	Field observation	Dalzell *et al.* (2006); 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 which determined critical P levels.

The legume response to soil P levels developed by Peck *et al.* (2015) are shown in Table 238. 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 238 – 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 48 (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 per 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 48 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 48 - Annual dry matter yield for low P requiring legumes in the year of fertiliser application (Peck et al. 2015).

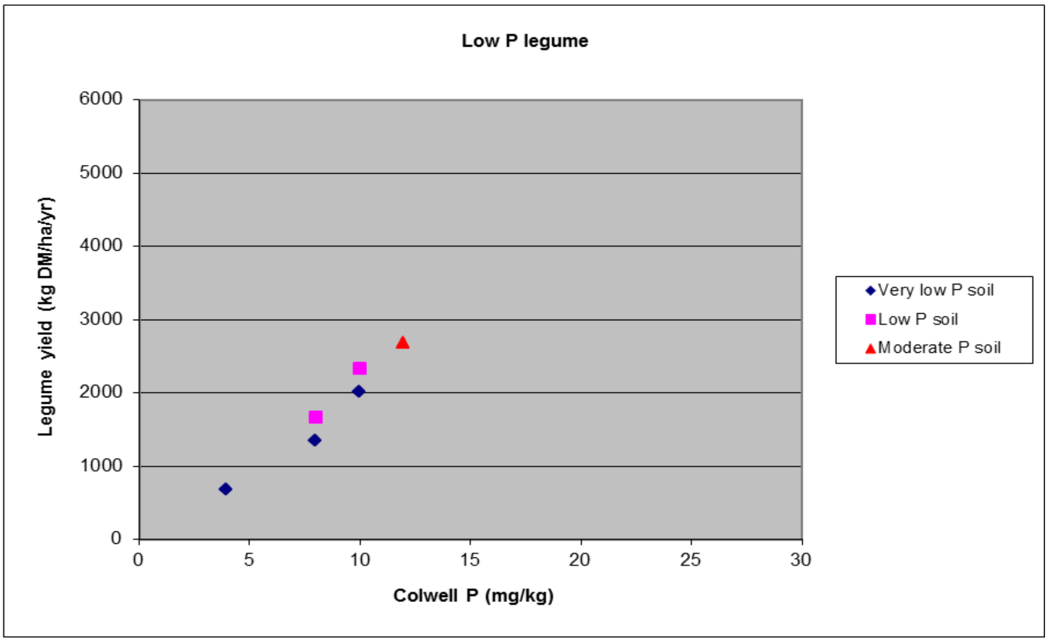
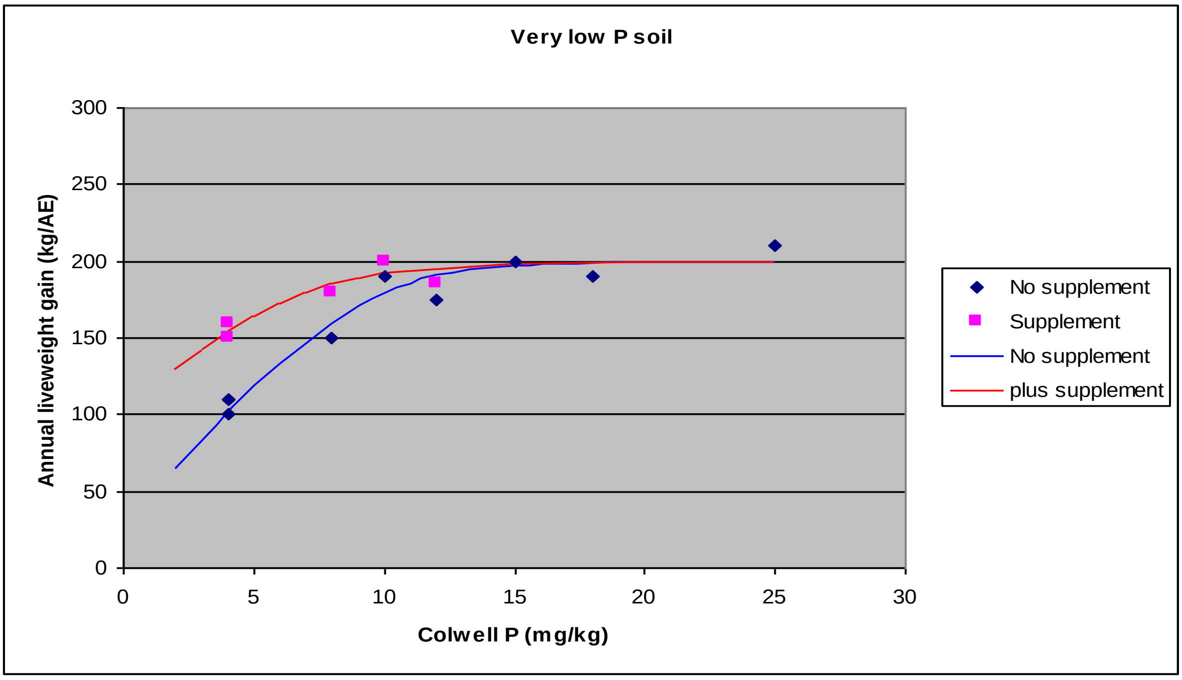


Figure 49 shows the summarised relationship developed by Peck *et al.* (2015) for supplemented or un-supplemented stock grazing legume-based pastures compared to soil P levels for a 'Deficient P' soil type.

Figure 49 - 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



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 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. The comparison was 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 48. 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 239 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 239 - 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 240). 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 49). 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 'adult equivalent' (AE). An adult equivalent was defined here 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 240 – 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 (adult equivalent); 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 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 241 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 241 –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.

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 242). 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 production systems.

Table 242 - Marginal 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.

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
Interest rate for NPV	5.00%	5.00%	5.00%
Marginal NPV	$194,959	$169,115	$198,142
Annualised marginal NPV (extra profit/year)	$12,682	$11,001	$12,889
Peak deficit (with interest)	-$70,636	-$60,909	-$59,842
Year of peak deficit	2	2	2
Payback period (years)	6	6	5
Marginal IRR	21.71%	22.13%	24.94%

7.6.5 Leucaena-grass pastures on Frontage country for steers

The perennial tree legume, leucaena (*Leucaena leucocephala* spp. *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, whole-farm case study analyses identified leucaena-grass systems as the most profitable forage option for beef cattle production in central Queensland (Bowen and Chudleigh 2017; Bowen and Chudleigh 2018*b*) 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).

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 comparison was the 500 ha paddock of Frontage country with and without leucaena development.

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 centre 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 243 and the development costs shown in Table 244.

Table 243 - 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

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 244 - 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 245 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 245 – 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 (adult equivalent); 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 'adult equivalent' (AE). An adult equivalent was defined here 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 246).

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 246 – 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.

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) of ca. $50,000 extra profit/year and a marginal return on the money invested in leucaena of ca. 16% (Table 247). However, the investment in a 500 ha paddock of leucaena-grass pastures for steers resulted in a substantial peak deficit for the enterprise 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.

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 leucaena-grass pastures on frontage country under Northern Gulf conditions over 30 years.

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; Bowen and Chudleigh 2018*b*) but with much greater IRR's, e.g. 33.51% and 25.8% 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.

Table 247 - Marginal 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 frontage paddock with and without leucaena development.

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
Interest rate for NPV	5.00%	5.00%	5.00%
Marginal NPV	$839,421	$711,751	$817,854
Annualised marginal NPV	$54,606	$46,300	$53,203
Peak deficit (with interest)	-$464,193	-$454,287	-$454,287
Year of peak deficit	5	5	5
Payback period (years)	10	10	10
Marginal IRR	16.18%	15.08%	16.54%

7.6.6 Silage for home bred steers

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.

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 248 shows the expected costs calculated at contract rates and Table 249 shows the cost per tonne of harvested forage.

Table 248 - 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 249 - 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 250 indicates the cost per tonne forage sorghum silage in the pit.

Table 250 - 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 251 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 251 - Silage ration cost per ton

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 252 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 252 - 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 253 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 253 - 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

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 254. About 40 c/kg liveweight more than the expected sale price would be required for the feeding exercise to be profitable.

Table 254 – 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 255 – 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 256 indicates the marginal or 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 256 - Marginal returns for feeding a home-grown forage sorghum silage ration to steers compared to a new base herd which is receiving adequate P supplementation and has benefited from 10 years of land condition improvement

Factor	**Value**
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	-$282,324
Annualised marginal NPV (extra profit/year)	-$18,366
Peak deficit (with interest)	-$784,055
Year of peak deficit	never
Payback period (years)	never
Marginal IRR	n/a

7.6.7 Silage for trading cull cows

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

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.

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 257 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 257 - 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 258 shows the expected costs calculated at contract rates and Table 259 shows the cost per tonne of harvested forage. Table 259 indicates the cost per tonne forage sorghum silage in the pit.

Table 258 - 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 259 - 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 260 - 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 261 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 261 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 261 - 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 262 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 262 - 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*

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 263). Note that cattle were valued going into the feeding operation at their value at the abattoirs.

Table 263 – Calculation of gross margin for cull cows a home-grown forage silage ration to achieve slaughter weights earlier

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 264. A marginal profit 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. 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 264 – 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

7.6.8 Annual strategy of sending steers on agistment

Agisting steers on a property with better quality land types than the currently owned or leased 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 marginal benefits are expected to be greater than marginal costs at both the gross margin and whole herd level.

This scenario considered the effect of sending steers 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 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 265 indicates the additional direct costs of sending the initial group of 227yearling 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 265 - 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 266 shows the expansion of the breeder herd if the agistment exercise were continued for a number of years.

Table 266 - 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

Table 267 indicates the marginal or 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.

Table 267 - Marginal 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

Factor	Value
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	-$116,499
Annualised marginal NPV (extra profit/year)	-$7,578
Peak deficit (with interest)	-$315,336
Year of peak deficit	never
Payback period (years)	never
Marginal IRR	n/a

Strategies that target the breeder component of the herd

7.6.9 Seeking a genetic improvement in fertility

Research has identified improvement in herd weaning rates and production efficiency 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, 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% in 10 years.

The expected benefits of converting the female herd running on country with improved land condition and receiving an adequate wet P supplement to a breeding herd with different genes for reproduction that provide a 6% improvement in overall weaning rates are tested.

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 268 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 268 - Modelled steps in genetic change of weaning rate with first year bull replacement at same cost

Herd Component	Base herd (Year 1)	Year 4	Year 6	Year 8	Year 10	Year 12
Total adult equivalents	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 269 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 269 - 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 270 shows the change in herd structure over the 16 years taken to fully implement the strategy.

Table 270 - Modelled steps in genetic change of weaning rate and herd structure with bulls replaced over time (Gradual bull replacement, same cost)

Herd component	Base	Year 4	Year 6	Year 8	Year 10	Year 14	Year 16
Total adult equivalents	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

The beef enterprise 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%: $4,114 extra profit/year (Table 271). 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 viable. The marginal return on extra capital is not inviting for what could be considered a 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 marginal NPV to replacement of the entire bull herd in Year 1: $6,761 (Table 271).

Table 271 - Marginal returns for investing in genetically superior bulls to improve breeder fertility compared to a base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

Factor	Year 1 bull change-over, same cost	Gradual bull change-over, same cost
Period of analysis (years)	30	30

Interest rate for NPV	5.00%	5.00%
Marginal NPV	$63,239	$103,934
Annualised marginal NPV (extra profit/year)	$4,114	$6,761
Peak deficit (with interest)	-$94,409	n/a
Year of peak deficit	5	n/a
Payback period (years)	17	n/a
Marginal IRR	9.17%	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*) where marginal 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 relatively high average base weaning rates: 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 % 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 marginal 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. 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.

7.6.10 Objectively selected home-bred bulls

Replacement bulls are a significant cost to the beef business. 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.

In this strategy, the potential economic impact of selecting breeding bulls from the male weaners was tested. It was assumed that 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 272 shows the structure and replacement strategy for the breeding bull herd for the base property.

Table 272 – 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).

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 about $16,000/annum added to the profit of the enterprise, on average, over the life of the investment (Table 273). 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 return on the investment from $16,600/annum to $13,600/annum. Currently herd recording systems in the region are rudimentary at best on many operations. Moving to home-bred bulls would require a significant step-up for most producers in identifying, recording and selecting superior females.

Table 273 - Marginal 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

Factor	Value
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	$255,390
Annualised marginal NPV (extra profit/year)	$16,613
Peak deficit (with interest)	-$24,975
Year of peak deficit	2
Payback period (years)	3
Marginal IRR	58.75%

7.6.11 Supplementing first calf heifers to improve re-conception rates

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.

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 274).

Table 274 - 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 275. One-off capital expenditure of $5,000 was required for troughs and feeding out equipment.

Table 275 – 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*

Table 276 shows the predicted investment returns for feeding M8U supplement to first calf, lactating heifers to achieve an improved re-conception. The investment reduced the average annual profit of the enterprise by about $3,479/annum.

Table 276 - Marginal returns for investment in M8U supplement for first calf heifers to improve re-conception rates compared to a base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

Factor	**Value**
Period of analysis (years)	30
Interest rate for NPV	5.00%
Marginal NPV	-$53,483
Annualised marginal NPV	-$3,479
Peak deficit (with interest)	-$147,068
Year of peak deficit	never
Payback period (years)	never
Marginal IRR	n/a

7.6.12 Reducing calf loss between conception and weaning

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 277). 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.

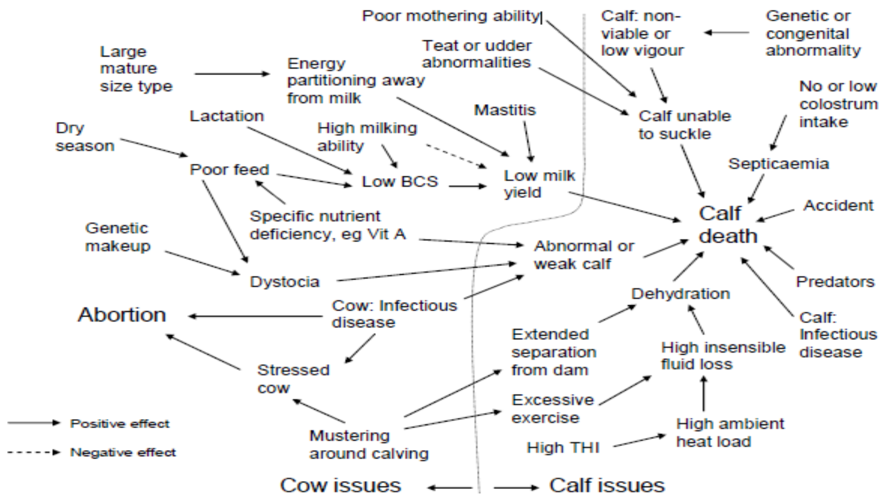
Table 277 - Median reproduction performance for Northern Forest data (McGowan et al. 2014)

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 50). 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 50 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 50 - Possible causal pathway for foetal and calf loss in northern Australia (McGowan et al. 2014)



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 enterprise 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 marginal returns achieved.

Table 278 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 enterprise, 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 by 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.

Table 278 - Marginal returns for investing to achieve a 50% reduction in calf loss across all breeding females compared to a base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

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
Interest rate for NPV	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Marginal NPV	$80,874	$34,964	-$10,947	$125,076	$101,266	$77,457
Annualised marginal NPV	$5,261	$2,274	-$712	$8,136	$6,588	$5,039
Peak deficit (with interest)	-$6,028	-$16,865	-$36,946	-$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

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9 Glossary and definitions

9.1 Risk, uncertainty and sensitivity analyses

Pannell (1996) outlines in detail the critical role of sensitivity analysis in herd and other economic modelling. That paper and the notes at http://www.pannelldiscussions.net/2008/06/126-sensitivity-analysis-with-economic-models/ can be referred to for more detailed information when completing a sensitivity analysis.

Sensitivity analysis is a core component of scenario analysis.

Pannell provides the following advice: *'Sensitivity analysis is the official term for "what if" analysis. It's one of the things that makes economic models so useful. We know that any given model is not totally accurate, and that the variables that drive it will vary somewhat unpredictably over time, but using sensitivity analysis we can still get useful information and insight from the model. It helps you to get a feel for the stability of results, identify the factors that most affect results, and estimate the probability of a strategy performing up to a required level'.*

There are clear reasons to include a consideration of risk and uncertainty in a scenario analysis. Pannell (1996) identifies "In all models, parameters are more or less uncertain. The modeller is likely to be unsure of the current values and to be even more uncertain about their future values. This applies to things like prices, costs, productivity and technology. Uncertainty is one of the primary reasons why sensitivity analysis is helpful in making decisions or recommendations. If parameters are uncertain sensitivity analysis can generate information like:

(a) How robust the optimal solution is in the face of different parameter values,

(b) Under what circumstances the optimal solution would change,

(c) How the optimal solution changes in different circumstances,

(d) How much worse off would the decision maker be if he or she ignored the changed circumstances and stayed with the original optimal strategy or some other strategy."

It is critical that the results of any formal Breedcow and Dynama modelling exercise have some form of sensitivity analysis applied, particularly where it is to be published. The notes and processes developed by Pannell (1996) are a very good guide as to how this should be undertaken.

9.2 Discounting and Investment Analysis

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

9.2.1 The need to discount

Investors generally prefer to receive a given amount of money now rather than receiving the same amount in the future. This is because money has an opportunity cost. For example, if asked an amount of money they would just prefer to receive in 12 months' time in preference to $100 now, most people would nominate a figure around the $110 mark (certainly more than $100!). In other words, money has an opportunity cost of around 10 per cent to them.

At an opportunity cost of 10 per cent, an amount of $100 now has a future value of $110 in 12 months' time ($100 x 1.1). It would have a future value of $121 in two years' time (i.e. $100 x 1.1 x 1.1).

For similar reasons, society puts an opportunity cost on funds employed in public sector development projects making discounting equally important in the allocation of public funds.

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

The general formula for discounting a future amount to its Present Value is:

Present Value = A / (1+i)n

where A = future amount; i = Discount rate; n = Number of periods in the future

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

Note that discounting is not carried out to account for inflation. Discounting would still be applicable in periods of nil inflation. It is common, however, to remove the inflation component from discount rates when undertaking investment analyses.

Nominal interest rates are those quoted on cash investments. Real discount rates have the inflation component removed from this nominal rate. It is also necessary that future cash inflows and outflows are expressed in real (constant) terms i.e. they should not include an allowance for inflation.

Alternatively, cash inflows and outflows may be expressed in current (nominal) dollar terms. In this situation a nominal (inflation included) discount rate would be used.

9.2.2 Profitability measures

Three profitability criteria can be calculated. They are:

- Net Present Value (NPV) - the stream of future cash flows is reduced to a single figure. The NPV is the difference between the Present Value (PV) of the investment inflows and the PV of the investment outflows. An investment is acceptable if the NPV is positive.
- Benefit-Cost Ratio (B/C Ratio) - the PV of the investment inflows divided by the PV of the investment outflows. An investment B/C ratio greater than one is required.
- The Internal Rate of Return (IRR) - the discount rate at which the PV of inflows equals the PV of outflows. It is internal because it is calculated independently of the cost of borrowed funds. It represents the maximum rate of interest that could be paid if all funds for the investment were borrowed and the investment was to break even.

The three decision criteria are interrelated. For example, at a discount rate of eight per cent:

NPV	Negative	Zero	Positive
IRR	< 8%	8%	>8%
BC RATIO	Less than 1	1	Greater than 1

9.2.3 "With" and "without" scenarios

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

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

Since the "with" change scenario is hypothetical by definition, specifying it is necessarily subjective, and consequently more problematic than the "without" change scenario. It should be inferred from the best available information, and the necessarily subjective underlying assumptions made explicit.

The specification of a counterfactual or baseline scenario is a key part of any impact analysis.

Use of the "with" and "without" principle forces formal consideration the net impact of the investment.

9.2.4 Compounding and discounting

Future costs and benefits can be valued in real (constant) or nominal (current) prices. In the real terms approach, all variables are expressed in terms of the price level of a single given year. While any year may be used, the present year will usually carry most meaning as a base.

Note that if an entire analysis is conducted in the prices of the year in which the analysis takes place, it is being carried out in real terms. The method assumes that future inflation will affect all costs and benefits even-handedly.

If there are good reasons for thinking that particular cost or benefit streams will not follow general price movements, those changes in relative prices should be built into the analysis. If land rents, for example, in the context of a property evaluation, are expected to exceed the rate of inflation by two per cent a year for the next three years, the analysis should include this parameter. Assumptions regarding expected relative price changes should be made explicit.

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

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

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

It is important that real prices and nominal prices are not confused in the analysis. In particular, when the analysis is presented in nominal prices, the discount rate should be adjusted for inflation.

This captures the point that investors require compensation for anticipated inflation as part of the price of making funds available. With annual compounding, the formula for converting a real discount (r) into a nominal one (n) is:

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

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

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

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

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

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

The criterion of choice in investment analysis is the Net Present Value (NPV) or the Internal Rate of Return (IRR). The NPV for individual investments can be converted to an annuity and presented as the "net annual economic benefit generated during the next x years." The Internal Rates of Return (IRR) is useful in comparing the likely returns of alternative investments but can be problematic when used inappropriately.

The Benefit Cost Ratio (B/C ratio) i.e. benefits in relation to costs is generally less used in investment analysis but is widely used in processes like Benefit Costs Analysis (BCA). A calculated B/C ratio of greater than one indicates a profitable investment.

It would be desirable to analyse all investments over a common time period e.g. 30 years. However, this will not always be possible because of different starting dates between investments and because of the different time frames over which benefits are likely to apply.

9.3 Glossary of key terms used in economic and financial analysis

Activity - Activity specifies a particular method of producing a crop or operating a livestock enterprise. For example, spring and winter wheat crops are considered as different activities but as the same enterprise. Cows fed three different rations and giving three levels of milk output can be treated as three separate activities.

Adult equivalent (AE): Cattle of different ages and body weight have different requirements for feed. In determining the composition and grazing pressure of a herd, it is necessary to work on a common animal unit. In this analysis an AE is defined 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.

Note: Adult Equivalents for dry cattle are based on relativity to a standard weight of beast carried for 12 months. AEs for breeders are based on weight, plus a loading for breeders that have (or wean) a calf. This loading represents the extra nutritional requirement of a cow that rears a calf, relative to a dry cow. The loading for rearing a calf can be between 20% and 35% of the loading given to the breeder depending upon the modelling process used and the age to which the cow calf unit is being assessed. The loading usually covers the extra load of pregnancy and lactation. In some models it will also cover the pasture consumed by the calf itself up to age five months, at which point the weaner can be rated in its own right.

Adult Equivalents are calculated for a PERIOD of time, not for a point in time. Except for weaners and sale cattle, this will be 12 months, e.g. from age 12 months to 24 months. The weaner group will usually be rated up until weaning for keepers and (more or) less for those sold.

One adult equivalent (AE) can be thought of as the amount of feed consumed in 12 months by a non-lactating animal of average weight 450 kg. Therefore, if average feed consumption is 22% of bodyweight, this would be equivalent to approximately 3,650 kg dry matter per year for one AE. Cattle supplemented with phosphorus or urea will eat more than un-supplemented cattle of the same bodyweight. For full-year supplementation, feed intake could be 20% higher than for un-supplemented cattle. When comparing herds with and without supplementation, reduce the total AE of the supplemented herd to ensure a fair comparison (17% reduction will equate to 20% extra feed consumption), applying pro-rata reduction for part-year supplementation.

Annuity: an equal sum spent or received; an amount paid or received annually or at other regular intervals for a stated period of time.

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.

Annual equivalent: A stream of equal amounts paid or received annually for a period such that discounting at an appropriate discount rate it will have a specified present worth. It is determined by multiplying an initial value by the capital recovery factor for the appropriate interest rate and period. To annualise is to find the annual equivalent of a value.

Benefit-cost analysis (BCA): A conceptual framework that can be applied to the economic evaluation of projects and programs in the public sector. It differs from a private financial appraisal (sometimes termed investment analysis) in that it considers all gains (benefits) and all losses (costs), regardless of to whom they accrue.

Benefit-cost ratio (B/C Ratio): The ratio of the present value of investment benefits to the present value of investment costs. A value greater than 1 suggests a profitable investment.

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'.

Constant (real) dollar terms: all variables are expressed in terms of the price level of a single given year.

Current (nominal) dollar terms: the impact of expected inflation is explicitly reflected in the cash flow projections.

Depreciation: (as applied in estimating operating profit). It is 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) divided by the 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. 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).

Dry sheep equivalent (DSE): Often defined as a two year old merino sheep (wether or non-lactating non-pregnant ewe). There are roughly eight DSEs to one AE. A DSE is often defined as the amount of feed required to maintain a 48 kilogram wether for a period of time, usually a year.

Economics - The science which studies human behaviour as a relationship between ends and scarce means which have alternative uses.

Economically sustainable- The use of various strategies for employing existing resources optimally so that a responsible and beneficial balance can be achieved over the longer term. Within an enterprise context, economic sustainability involves using the capital of the company efficiently to allow it to continue functioning over time.

Enterprise - Enterprise denotes the production of a particular commodity or group of related commodities for direct sale, thus by 'wheat enterprise' we imply the production and sale of a wheat crop but do not specify the method of production.

Enterprise (or Activity) gross margin - The gross margin of an enterprise (or activity) is its gross income minus its variable costs.

Enterprise (or Activity) variable costs - Costs directly attributable to an enterprise or activity and which vary in direct proportion to the scale of the enterprise or activity.

Equity capital: The value of the owner's capital. This is equal to total capital minus total liabilities.

Equity Ratio (or per cent) - The proportion of equity capital to total capital, usually expressed as a percentage.

Farm budget: Accounts for the gross margins of each of the enterprises considered as well as the fixed or overhead costs of the farm (also called a profit and loss statement). Usually includes a statement of farm assets and liabilities (or a balance sheet) and a cash flow budget.

Fixed (or overhead) costs - Defined as costs which are not affected by the scale of the activities in the farm enterprise. They must be met in the operation of the farm.

Examples include: wages and employee on-costs, repairs, insurance, shire rates and land taxes, depreciation of plant and improvements, consultants fees and the operators allowance for labour and management. Some fixed costs (such as depreciation or operator's allowance) are not cash costs. It is usual to count the smaller amounts of interest on a typical overdraft or short term working capital as an operating expense (fixed cost) and deducted in the calculation of operating profit. The returns to lenders of fixed capital (interest, rent, lease payments) are deducted in the calculation of net profit.

Gross margin: A gross margin is the gross income from an enterprise less the variable costs incurred in achieving it. It excludes fixed or overhead costs.

Internal Rate of Return (IRR): 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; the breakeven discount rate = the maximum interest that a project can pay for the resources used if the project is to recover its investment and expenses and still just breakeven.

Investment appraisal: An evaluation of the profitability of an investment.

Investment criteria: Are measures of the economic worth of an investment such as Net Present Value, Benefit-Cost Ratio and Internal Rate of Return.

Key Performance Indicators (KPI's): Key performance indicators (KPI's) are tracking indicators used to measure the achievement of outputs against targets.

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.

Live Stock Unit (LSU): see Adult Equivalent

Marginal return: extra or added return. Principle of marginality emphasises the importance of evaluating the changes for extra effects, not the average level of performance.

n/a Not applicable or not able to be calculated

NPV Net present value. Refers to the net returns (income minus costs) over the life of an investment (in this case, provision of high quality forages), 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 preferred. NPV was calculated at a 5% rate of return which was taken as the real opportunity cost of funds to the producer. NPV can be expressed as the total business returns or as the marginal return – referred to as the Marginal NPV in this report. Marginal NPV is the extra return received as a result of the investment.

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 enterprise 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.

Nominal (current) terms: the impact of expected inflation is explicitly reflected in the cash flow projections.

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 enterprise 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.

Other farm income - Income earned by the farm enterprise but not attributable to a particular enterprise, such as income from contract work.

Overhead (or Fixed) costs - see Fixed costs.

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.

Present Value of Benefits (PVB): The discounted value of a stream of future benefits.

Present Value of Costs (PVC): The discounted value of a stream of future costs.

PI: Persistently infected animal. PI refers to cattle born after exposure to the pestivirus (bovine viral diarrhoea virus) disease in utero during the first trimester of gestation.

PTE: Pregnancy tested empty (not in calf)

PTIC: Pregnancy tested in calf

Operating Profit: This is the return to total capital invested after the variable and overhead (fixed) costs involved in earning the revenue have been deducted. Operating profit represents the reward to all of the owners of the capital tied up in the enterprise. Operating profit equals (total receipts minus variable costs equals' total gross margin) minus overheads. When operating profit is expressed as a percentage return to total capital it indicates the efficiency of the use of all of the capital invested in the farm enterprise.

Stochastic: A process with an indeterminate or random element as opposed to a deterministic process that has no random element.

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.

Rate of return on equity - Net Profit expressed as a percentage of the average of the owner's equity capital used in the enterprise for the period under review (usually a year).

Rate of return on total capital - Operating Profit expressed as a percentage of the average of the total capital employed for the period under review (usually a year).

Real (constant) dollar terms: all variables are expressed in terms of the price level of a single given year.

Reproduction efficiency is defined as the number of weaners produced divided by the total number of breeders mated expressed as an annual percentage.

Risk analysis: An analysis or an assessment of factors that affect or are likely to affect the successful achievement of an intervention's objectives. A detailed examination of the potential unwanted and negative consequences to human life, health, property, or the environment posed by interventions; a systematic process to provide information regarding such undesirable consequences; the process of quantification of the probabilities and expected impacts for identified risks.

Sensitivity analysis: An analytical technique to test systematically what happens to earning capacity if events differ from the estimates made about them in planning.

Total Capital - The total value of the capital of the farm enterprise, such as land, improvements, livestock, plant and materials.

Total gross margin: The sum of the gross margins of all the enterprises or activities in the farm plan.

Total liabilities: The total value of the liabilities of the farm enterprise, such as bank debt, unpaid accounts, tax due etc.

Variable costs: costs which change according to the size of an activity. The essential characteristic of a variable cost is that it changes proportionately to changes in enterprise size (or to change in components of the enterprise).