ECONOMIC CONSEQUENCES OF SELECTION FOR COW FERTILITY IN NORTHERN AUSTRALIAN BEEF HERDS

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Introduction

This paper reports on a desktop modelling analysis undertaken to compare the contribution to both beef herd productivity and profitability associated with selection for cow reproduction within representative Northern Australian beef cattle herds.

With increasing industry awareness of the importance of reproduction rates within Northern Australian beef enterprises, and the opportunities to improve this via genetic selection, it is timely to evaluate the economic benefits associated with improved fertility. Furthermore, with such diversity of pastoral landscape, beef markets and beef enterprises, it is also important to evaluate whether benefits associated with improved breeding cow fertility are consistent across different region x enterprise scenarios.

By comparing economic responses from consistent, genetically-achievable improvements in herd fertility, this work will help inform whether distinct regional or enterprise factors shape the economic benefits associated with selection for beef cow fertility in Northern Australia.

With many key Northern Australian beef breeds offering a limited range of selection indexes to support bull selection decisions across the diverse environments and productions systems, this research will identify whether greater diversity of selection indexes is required to reflect differences in economic response to improved cow fertility.

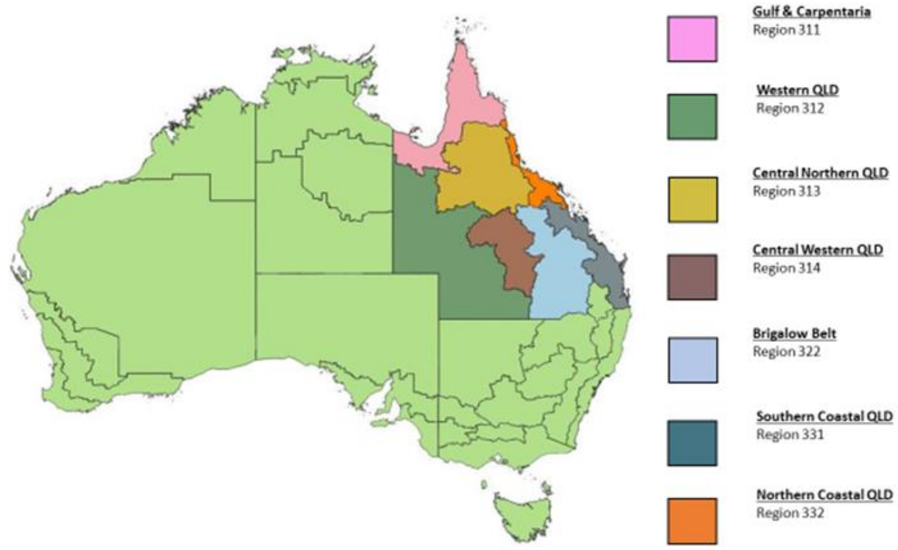
As a secondary objective, the potential benefits associated with increased animal growth and size were explored, to confirm the accuracy of current relative weightings on fertility and growth traits within Northern Australian selection indexes.

Methodology

An integrated herd and business model was developed to analyse the change in profit associated with genetic improvement of breeding cow fertility within models of representative beef cattle businesses from seven regions of Queensland.

The seven regions represent a diverse mix of environments and production systems, with models configured to reflect an equally diverse range of beef enterprise types.

Figure 1. Location Map of Regional Herd Models



The analysis compared the profit response associated with a genetic standard deviation (σg) improvement of cow fertility via selection for heifer pregnancy rate.

Heifer Pregnancy Rate (HP%) was utilised as the key female reproduction trait as this trait had been extensively measured within the research project described within this report.

Analysis was also undertaken to model responses to 600 Day Weight (600DW), a key growth trait used in most BREEDPLAN Analyses. Inclusion of 600DW was undertaken to provide context to the productivity and profit responses associated with genetic improvement of fertility. Pre-joining weights collected within the associated research project were used for estimation of 600DW.

Regions were classified as either Brahman or Crossbred, based on the expected predominant breed type. Regions 311, 313, 331 and 332 were classified as Brahman, whilst 312, 314 and 322 were classified as crossbred. Breed classification determined the source of genetic parameters utilised within the modelling for calculation of responses in correlated traits.

A key feature of the modelling was the use of estimated genetic variances estimated at a regional level. This ensured that modelling of responses to selection reflected consistent levels of selection intensity across each trait and region. This approach also ensured that modelled levels of phenotypic response were achievable via genetic selection and did not require complimentary environmental or management changes.

The model was configured to project the steady state response to selection for the target trait at the level of a genetic standard deviation (*σg).*

Responses to selection in non-target and associated traits were projected via slope coefficients from linear regression models. These models were populated with data from Breedplan EBVs from 2016-born Brahman and Santa Gertrudis cattle (EBVs accessed September 2018).

Once the changes to each trait had been quantified, the model mapped these adjustments to each affected part of the baseline Regional Herd Model Template to determine the applicable changes to herd production and herd profile.

The model then reconfigured cattle numbers to fit the changed herd to the same AE capacity as the baseline herd.

The modelling project adopted a steady state basis of comparison between the baseline model and the simulations, no transition phase was modelled.

Results and Discussion

Selection for fertility produced favourable profit responses in all regions and demonstrated the opportunity for genetic improvement of fertility to enhance the profitability of Queensland beef businesses. However, economic benefits associated with improvement of fertility were greatest in extensive pastoral regions.

Table 5 displays the percentage change in herd gross margin (GM) across target each trait and region combination.

Table 1. % Change in Gross Margin per AE by Target Trait

	311	312	313	314	322	331	332
HP % GM Change	+$6.27	+$5.30	+$3.01	+$3.92	+$3.27	+$2.49	+$3.87
HP% GM Change %	5.2%	4.3%	2.9%	3.0%	1.9%	1.6%	3.1%
600DW GM Change	+$1.34	+$1.42	+$2.81	+$1.83	+$0.50	+$1.53	+$3.18
600DW GM Change %	1.1%	1.1%	2.7%	1.4%	0.3%	1.0%	2.6%

The greater benefits from fertility improvement in extensive regions was caused by several factors. Firstly, differences in regional genetic parameters caused different levels of response across regions, with greater relative response within extensive regions. This potentially reflects the importance of genetic merit within more marginal and limiting environments.

Secondly, regional differences in baseline reproductive rates, mortality rates, target markets, age of turnoff and breeder culling systems, all caused subtle differences in herd structure that shaped the herd-level response to each trait.

Selection for growth via 600DW produced a positive response in all regions, albeit at lower levels than HP%. This was primarily due to the correlated response in Mature Cow Weight, whereby the benefits of larger and faster growing steers and heifers were partially offset by larger cows. Whilst selection for growth did produce favourable responses in sale weight, fewer animals were produced for sale due to the need to reduce and rebalance breeder numbers to accommodate correlated increases in cow size and maintain constant grazing load.

These results are consistent with the relative trait weightings applied to fertility and growth within selection indexes utilised by most key Northern Australian beef breeds. Most key selection indexes currently feature significantly greater selection weighting applied to fertility via the Days to Calving EBV.

However, the results highlight divergence in the economic responses to improved breeding cow fertility across extensive and intensive regions of Queensland. At a consistent level of selection intensity, economic benefits from improved fertility in extensive regions were estimated to be double the benefit of intensive regions. These results strongly suggest that herds operating within extensive regions of Northern Australia could benefit from increased emphasis on breeding cow fertility traits relative to herds in more intensive regions.

Introduction

This paper reports on a desktop modelling analysis undertaken to compare the contribution to both beef herd productivity and profitability associated with selection for cow reproduction within representative Northern Australian beef cattle herds.

The profitability of beef enterprises in Northern Australia depends on livestock productivity, particularly reproduction rates (McLean et al. 2014). The majority of these enterprises do not achieve economically sustainable levels of profitability (McLean et al. 2014).

Johnston et al. (2014) showed that significant genetic variation in reproductive performance existed both within and across contemporary group populations of Brahman and Tropical Composite breeding females. Meanwhile, McGowan et al. (2014) uncovered significant variation in commercial beef cattle reproductive performance both within and across regions of Northern Australia.

With increasing industry awareness of the importance of reproduction rates within Northern Australian beef enterprises, and the opportunities to improve this via genetic selection, it is timely to evaluate the economic benefits associated with improved fertility. Furthermore, with such diversity of pastoral landscape, beef markets and beef enterprises, it is also important to evaluate whether benefits associated with improved breeding cow fertility are consistent across different region x enterprise scenarios.

By comparing economic responses from consistent, genetically-achievable improvements in herd fertility, this work will help inform whether distinct regional or enterprise factors shape the economic benefits associated with selection for beef cow fertility in Northern Australia.

With many key Northern Australian beef breeds offering a limited range of selection indexes to support bull selection decisions across the diverse environments and productions systems, this research will identify whether greater diversity of selection indexes is required to reflect differences in economic response to improved cow fertility.

As a secondary objective, the potential benefits associated with increased animal growth and size were explored, to confirm the accuracy of current relative weightings on fertility and growth traits within Northern Australian selection indexes.

This research represents a component of a larger research project undertaken by the Queensland Alliance for Agriculture Food and Innovation (QAAFI) that is seeking to develop genomic predictions for heifer reproduction traits. Unpublished data from this project has been used within the analysis undertaken for this paper.

Glossary

Acronym or Abbreviation	Term	Definition
AE	Adult Equivalent	Standard animal unit. A 450kg *Bos taurus* steer at maintenance.
GM	Gross Margin	Herd revenue minus direct costs (animal health, freight and marketing, supplementation etc).
EBIT	Earnings Before Interest & Tax	Herd revenue minus direct costs and overhead expenses. Excludes finance costs and tax.
ROA	Return on Assets	EBIT divided by total business assets
EBV	Estimated Breeding Value	Statistical prediction of genetic merit representing expected difference in performance for a given trait relative to breed average
H^2	Heritability	The proportion of variation in phenotype attributable to genetic differences between animals where $H^2 = Vg/Vp$
σp	Phenotypic standard deviation	Measure of overall variability for a given trait
σg	Genetic standard deviation	Measure of genetic variability for a given trait
Vp or σ^2p	Phenotypic variance	Measure of overall variability for a given trait where $Vp = \sigma^2p$
Vg or σ^2g	Genetic variance	Measure of genetic variability for a given trait where $Vg = \sigma^2g$
rg	Genetic correlation	Measure of the strength of relationship between two traits
WW	Weaning Weight	Trait evaluating differences in weight at weaning or approximately 6 months of age
600DW	600 Day Weight	Trait evaluating differences in weight at 600 days of age
HP%	Heifer Pregnancy Rate	Trait evaluating differences in pregnancy rate among heifers at their first mating
P8F	P8 Fat	Trait evaluating differences in carcass fat cover at the P8 (rump) site
EMA	Eye Muscle Area	Trait evaluating differences in surface area of the eye muscle (*longissimus dorsi*) at the 12th rib site
FCHR%	First Calf Heifer Conception Rate	Trait evaluating differences in pregnancy rate between heifers at their second mating
MCC%	Mature Cow Conception Rate	Trait evaluating differences in pregnancy rate between mature cows from their third mating onwards
400DW	400 Day Weight	Trait evaluating differences in weight at 400 days of age
BY%	Beef Yield Percentage	Trait evaluating differences in carcass yield (hot standard carcass weight as a % of slaughter live weight)
DTC	Days to Calving	Trait evaluating differences in time between mating and calving, measuring combined

Acronym or Abbreviation	Term	Definition
		differences in time for cows and heifers to achieve a pregnancy, as well as subsequent differences in gestation length
MCW	Mature Cow Weight	Trait evaluating differences in weight of mature cows (over five years of age)

Methodology

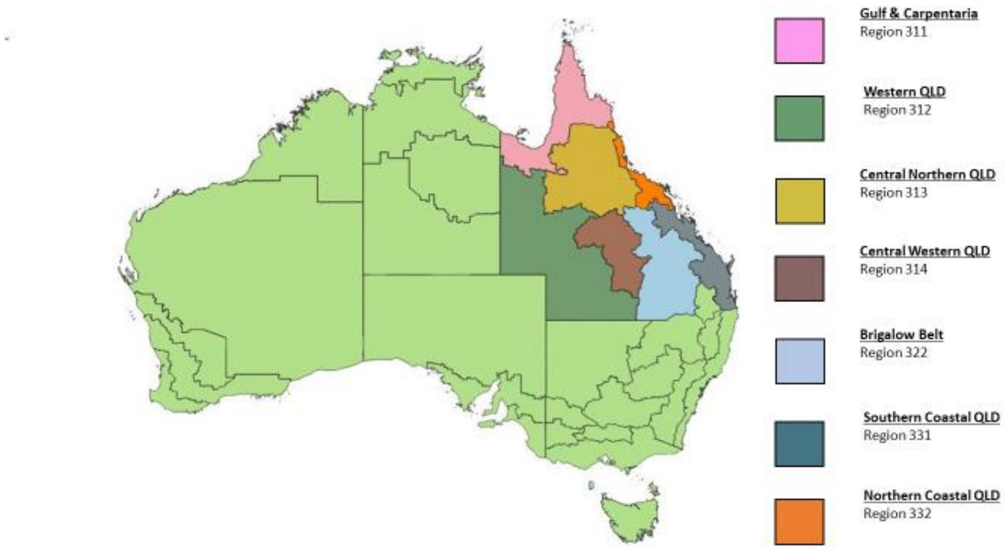
Establishing Baseline Models of Typical Regional Beef Businesses

A herd and business model was constructed based on the design of the Breedcow-Dynama herd modelling software developed by the Queensland Department of Agriculture and Fisheries (DAF, 2015). The model incorporates detailed descriptions of herd structure and turnoff/sale parameters, and animal growth, mortality and reproductive rates for various animal ages and classes. Most importantly the model incorporates the ability to cap the herd at a specified carrying capacity in Adult Equivalents (AEs), reconfiguring cattle numbers to maintain the herd within the specified carrying capacity. This process ensures that calculated profit changes only resulted from changes in production efficiency, and not due to an increased herd size. This feature ensured a consistent grazing load was modelled across each scenario as herd profile and output changed in response to selection.

The key difference between the developed model and Breedcow-Dynama was the adoption of a changed set of AE parameters derived from McLean and Blakeley (2014). An AE is defined as a 27-month-old 450kg Bos Taurus steer at maintenance (McLean and Blakeley, 2014).

Models of regionally representative herds for seven Queensland regions were adapted from DAF (2015). Regional models (based on ABARES survey region boundaries) were selected for Gulf of Carpentaria and Cape York (Region 311), Western Queensland (Region 312), Central Northern Queensland (Region 313), Central Western Queensland (Region 314), Brigalow Belt (Region 322), Southern Coastal Queensland (Region 331) and Northern Coastal Queensland (Region 332). Figure 2 depicts the location of each region.

Figure 2. Location Map of Regional Herd Models



Each DAF (2015) Regional Herd Model Template was developed by Departmental research and extension staff to represent typical herd production parameters (growth rates, reproductive rates, mortality rates) and management strategies (culling and sale strategies) representative of commercial beef enterprises within the region.

These models were utilised as a static, steady state performance baseline for 'typical' beef businesses within each region.

Updates were undertaken to update template cattle prices and direct costs, whilst age of turnoff parameters and reproductive rates were adjusted to reflect regional performance observed in Holmes *et al*. (2017) and McGowan *et al*. (2014).

Establishing Regional Genetic Parameters for Cow Reproduction

Heifer Pregnancy Rate (HP%) was utilised as the key female reproduction trait as this trait had been extensively measured within the research project described earlier within this paper.

Alternate traits for the improvement of female reproductive performance are discussed later.

Analysis was also undertaken to model responses to 600 Day Weight (600DW), a key growth trait used in most BREEDPLAN Analyses. Inclusion of 600DW was undertaken to provide context to the productivity and profit responses associated with genetic improvement of fertility. Pre-joining weights collected within the associated research project were used for estimation of 600DW.

Regions were classified as either Brahman or Crossbred, based on the expected predominant breed type. Regions 311, 313, 331 and 332 were classified as Brahman, whilst 312, 314 and 322 were classified as crossbred. Breed classification determined the source of genetic parameters utilised within the modelling for calculation of responses in correlated traits.

A key feature of the modelling was the use of estimated genetic variances estimated at a regional level. This ensured that modelling of responses to selection reflected consistent levels of selection intensity across each trait and region. This approach also ensured that modelled levels of phenotypic response were achievable via genetic selection and did not require complimentary environmental or management changes.

The latter represented a critical assumption applicable to the modelling. It was assumed that phenotypic changes attributable to genetic improvement could be undertaken without affecting overhead costs or capital deployed in non-livestock assets. This would enable modelling of gross margin changes as the sole impact of the change in underlying herd genetics. Genetic improvement simply requires a change in bull purchasing practices without requiring changes to overhead costs such as labour and fuel, or capital investment in plant and equipment, infrastructure and pastures. The authors did not assume that changes to bull selection practices would necessarily increase the cost of replacement bulls as, particularly in Australian tropical breeds, there is little evidence of genetic merit (as described by Estimated Breeding Values and selection indexes) influencing bull sale values.

Table 2 displays the genetic variance ($\sigma^2 g$) assumed in the analysis for each trait and region combination. Regional genetic parameters for HP% and 600DW were calculated from unpublished phenotypic data available from the associated research project. In calculating σ2g for HP%, heritability (h2) was assumed to be 0.15 for Brahmans and 0.05 for crossbreds based on Corbet et al. (2017), whilst 600DW h2 was assumed to be 0.4.

Table 2. Regional genetic variance ($\sigma^2 g$) parameters

	R311[1]	R312[1]	R313[1]	R314[2]	R322[2]	R331[2]	R332[1]
HP% (%)	0.019	0.009	0.015	0.008	0.007	0.011	0.023
600DW (kg)	652	490	612	455	420	523	706

1. Extensive region
2. Intensive region

Modelling Responses to Selection

The model was configured to project the steady state response to selection for the target trait at the level of a genetic standard deviation (*σg).*

For HP%, correlated responses in first calf heifer re-conception rate (FCHR%) and mature cow conception rate (MCC%) were estimated to enable an estimate of the response to fertility selection at a whole-of-herd level.

Similarly, correlated responses to 600DW selection were also modelled across all age classes via correlations with Weaning Weight, Yearling Weight and Mature Cow Weight. In addition, correlated responses in P8 Fat (Rump Fat) and Carcass Yield were also estimated following selection for 600DW.

The associated traits were included as these were equally influential in determining herd production and structure but had been primarily omitted from the modelling as a target trait in order to manage the volume of region x trait combinations incorporated into the analysis.

The analysis ignored correlations with traits such as birth weight (and its interaction with calving ease/dystocia), scrotal size (and its interaction with bull fertility), carcass marble score, and temperament.

Responses to selection in non-target and associated traits were projected via slope coefficients from linear regression models whereby response in the correlated trait was equal to the response in the target trait (x trait) multiplied by the genetic regression slope coefficient for the correlated trait (y trait). These models were populated with data from Breedplan EBVs from 2016-born Brahman and Santa Gertrudis cattle (EBVs accessed September 2018).

Given that HP%, FCHR% and MCC% are not standard Breedplan traits, the relationships between these traits was established from Johnston *et al.* (2014).

Carcass price grid specifications and non-compliance discounts were obtained from online pricing grids from Teys Australia (2018) for grassfed cattle at their Rockhampton plant (accessed September 2018). Saleyard data for Roma saleyard over 2016-2018 (Meat & Livestock Australia, 2018) was used for categories of store cattle.

Once the changes to each trait had been quantified, the model mapped these adjustments to each affected part of the baseline Regional Herd Model Template to determine the applicable changes to herd production and herd profile. Changes in female reproduction parameters were reflected in changes to the sales of surplus and cull females where it was reflected in the baseline model that reproductive outcomes were a determinant in female retention and culling decisions.

The model then reconfigured cattle numbers to fit the changed herd to the same AE capacity as the baseline herd. The model subsequently automatically recalculated sales revenue and direct costs to match the relevant changes to the herd and its output. Overhead costs and capital (except livestock capital) were assumed to be independent of genetic selection practices and were held constant across each regional scenario.

The modelling project adopted a steady state basis of comparison between the baseline model and the simulations, no transition phase was modelled.

Results

Results from the modelling can be classified into three sequentially related areas:

1. Trait selection responses
2. Herd responses to selection
3. Profit responses

Trait Selection Responses

Tables 3 and 4 display the response to selection for each target trait and region.

Table 3. Response to Selection for HP% Across Female Classes and Region

Trait	311	312	313	314	322	331	332
HP% change (%)	13.9%	9.4%	12.3%	9.0%	8.5%	10.5%	15.1%
FCHR% change (%)	-0.3%	5.1%	-0.3%	4.8%	4.6%	-0.2%	-0.3%
MCC% change (%)	2.9%	5.1%	2.5%	4.8%	4.5%	2.1%	3.2%

Table 4. 600DW Selection Responses by Region

Trait	311	312	313	314	322	331	332
600DW (kg)	25.5	22.1	24.7	21.3	20.5	22.9	26.6
Wean Weight (kg)	10.4	11.0	10.0	10.6	10.1	9.3	10.8
Yearling Weight (kg)	15.6	15.4	15.2	14.8	14.2	14.0	16.3
Mature Cow Weight (kg)	33.4	27.1	32.4	26.1	25.1	30.0	34.8
P8 Fat (mm)	-0.8	-0.5	-0.7	-0.5	-0.4	-0.7	-0.8
Yield (%)	0.4	0.4	0.4	0.3	0.3	0.4	0.5

Responses to selection for HP% were greatest in Regions 311, 313 and 332 due to observed higher levels of regional genetic variance. Johnston *et al.* (2014) reported divergent relationships between Brahmans and Tropical Composites for maiden heifer pregnancy rate and both 1st lactation heifer pregnancy rate and mature cow pregnancy rate, as evident in Table 3 above. It was hypothesised that this reflected greater genotypic tendency for Brahmans to exhibit post-partum anoestrous.

Overall herd-level weaning rate responses to selection for HP%, as displayed in Table 3, were consistent with observed regional variation reported by McGowan *et al.* (2014).

Growth trait responses were similar in absolute terms, though higher in relative terms in extensive regions due to the lower underlying growth rates and sizes.

Herd Responses to Selection

Herd responses to selection were shaped by the interaction with weaning rates, and changes in animal sizes, growth rates and class AE ratings.

Whilst the direct response to selection for HP% was highest in extensive regions, due to higher genetic variance, overall weaning rate response was highest in other regions due to the correlated response patterns of crossbreds. In relative terms changes in weaning rate were similar due to the lower reproductive rate of the extensive (predominately Brahman) regions.

Changes in average sale weight were of similar magnitude across regions. Whilst interactions with growth and size were the primary drivers of these changes, subsequent impacts on herd structure and sale composition (numbers of surplus heifers and cull breeders) also contributed to sale weight effects.

Interactions with herd composition and output are summarised in Table 5 below.

Table 5. Changes in Herd Structure and Output

		R311	R312	R313	R314	R322	R331	R332
Base	AE Carried	6,513	4,842	3,705	2,107	1,757	1,119	1,108
	Head Carried	6,974	4,074	3,489	1,765	1,127	976	1,131
	Breeders Mated	4,138	2,176	1,895	861	625	503	503
	Calves Weaned	2,255	1,594	1,200	662	505	360	338
	Cattle Sold	1,976	1,460	1,091	627	485	343	318
HP%	AE Carried	6,513	4,842	3,705	2,107	1,757	1,119	1,108
	Head Carried	6,905	4,042	3,471	1,759	1,118	972	1,124
	Breeders Mated	4,007	2,096	1,847	825	619	492	482
	Calves Weaned	2,331	1,650	1,232	679	532	367	348
	Cattle Sold	2,053	1,515	1,124	643	513	350	328
600DW	AE Carried	6,513	4,842	3,705	2,107	1,757	1,119	1,108
	Head Carried	6,461	3,830	3,263	1,667	1,074	918	1,047
	Breeders Mated	3,833	2,046	1,772	813	596	473	465
	Calves Weaned	2,089	1,499	1,122	626	481	338	312
	Cattle Sold	1,830	1,372	1,020	592	463	332	295

Regardless of region the modelling produced a generic pattern of response across each target trait. This pattern triggered consistent outcomes at the herd level.

Generally, selection for growth traits (WW and 600DW) increased animal size, growth rate and sale weight. Female breeder sizes increased as well as younger cattle due to the strong correlation between 600DW and MCW (rg = 0.88 for Brahman and 0.81 for crossbreds for 600DW and MCW). As a consequence of increased growth and size, AE ratings of all classes increased, this resulted in a fewer number of cattle being carried within the stated AE carrying capacity of the herd. Gains in animal sale weight were at least partially offset by fewer animals being carried and sold.

Selection for HP% enhanced reproductive rates across the entire breeding herd. Responses were different depending on breed type, Brahmans exhibited a greater response in heifers and a lower response in older breeder classes.

Greater breeder herd efficiency also increased cattle sale volumes as weaning rates increased.

Profit Responses

Table 6 displays the absolute and percentage change in herd gross margin (GM) across each target trait and region combination.

Table 6. % Change in Gross Margin per AE by Target Trait

	311	312	313	314	322	331	332
HP % GM Change	+$6.27	+$5.30	+$3.01	+$3.92	+$3.27	+$2.49	+$3.87
HP% GM Change %	5.2%	4.3%	2.9%	3.0%	1.9%	1.6%	3.1%
600DW GM Change	+$1.34	+$1.42	+$2.81	+$1.83	+$0.50	+$1.53	+$3.18
600DW GM Change %	1.1%	1.1%	2.7%	1.4%	0.3%	1.0%	2.6%

HP% produced the greatest change in profit across all regions, with greater relative response in extensive regions.

Discussion

Impact on Profitability

Holmes *et al.* (2017) analysed the profitability of a large sample of Australian beef businesses over 2004 to 2016. In Northern Australia, differences in profit (EBIT) per AE between the average and the most profitable quartile (Top 25%) were estimated to be approximately $57 per AE. Differences in gross margin per AE only accounted for $20 per AE with the remainder of the EBIT difference due to lower overhead expenses driven largely by economies of scale.

The modelling revealed uplifts in profitability toward the lower end of the gross margin variation observed in Holmes *et al.* (2017). This is somewhat understandable given the broader range of factors contributing to variation in gross margin within the Holmes *et al.* (2017) analysis. These broader factors included differences in profitability attributable to target markets, management systems and expertise, intra-regional differences in land and pasture productivity, as well as genetic differences.

Despite this the authors believe the opportunities to improve beef business profitability via genetics are understated within the results of this analysis.

Firstly, the modelling displays the profit impact resulting from a change of a single genetic standard deviation. The adoption of a genetic standard deviation as the standard level of selection intensity simply represented an attempt to identify and impose a consistent level of selection intensity and did not represent the author's perception of the maximum level of achievable genetic improvement.

Genetic improvement beyond that projected within this paper is achievable and the benefits are cumulative.

Secondly, the modelling process represented a focus on selection for a single trait in isolation from other economically important traits. It is well established that the adoption of a balanced breeding objective that seeks to simultaneously improve multiple traits is superior to pursuing a single trait approach to selection (Bourdon, 1992).

Finally, the benefits associated with selection for improved reproduction via selection for HP% were perhaps understated by the choice of target trait. This trait choice was driven by the availability of regional data. Johnston *et al.* (2014) identified several heifer traits with stronger relationships to lifetime reproductive performance than HP%. The number of calves weaned across the first two matings possessed a genetic correlation of 0.84 for Brahmans and 0.92 for Tropical Composites to lifetime annual weaning rate, whilst Days to Calving in first lactation heifers possessed a genetic correlation of -0.96 (Brahmans) and -0.76 (Tropical Composites) to lifetime annual weaning rate. As a consequence, the selection of different female reproduction traits could have driven greater selection responses than reported here for HP%.

Nonetheless the authors believe that these results demonstrate the opportunity for genetic improvement to contribute to enhanced profitability. Given the ease with which the trait focus of breeding objectives and sire selection practices can be adjusted, and the apparent lack of connection between sire EBVs and sire sale value in Northern Australia, genetic improvement represents a significant opportunity to enhance profitability.

Variation in Profit Impact Across Regions

Selection for HP% produced favourable profit responses in all regions. Furthermore, these profit responses exceeded those produced for 600DW in each region.

Economic responses were greatest in extensive regions, increasing herd gross margin by 5.2%, 4.3%, 2.9% and 3.1% in Regions 311, 312, 313 and 332 respectively. By contrast, profit responses within intensive regions were 3.0%, 1.9% and 1.6% in Regions 314, 322 and 331.

The greater benefits from fertility improvement in extensive regions was caused by several factors. Firstly, differences in regional genetic parameters caused different levels of response across regions, with greater relative response within extensive regions (see Table 2). This was not entirely indicative of genotype differences across regions as 312 within the extensive regions was assumed to be a crossbred genotype, while 331 within the intensive regions was assumed to be a Brahman genotype. This potentially reflects the importance of genetic merit within more marginal and limiting environments.

Secondly, regional differences in baseline reproductive rates, mortality rates, target markets, age of turnoff and breeder culling systems, all caused subtle differences in herd structure that shaped the herd-level response to each trait. Models for the extensive regions mostly assumed steers were held for a wet season after weaning and subsequently sold the following year as a yearling (except Region 313). This would typically represent a focus on live export markets or the sale of store cattle to backgrounders and restockers. In some intensive regions steers were assumed to be carried for an extra year and sold between two and three years of age. Depending on region, this would represent either production of export feeder cattle, or finished slaughter cattle.

The consequences of the older age of turnoff within the intensive regions also comprised the need to reduce breeders (and replacement heifers) to accommodate the extra age group of steers. In addition, higher reproductive rates and lower mortalities resulted in a smaller proportion of the herd being retained as breeders and breeder replacements (unjoined heifers being grown out prior to joining). As a result, benefits associated with improved reproduction rates accrued to a smaller proportion of the overall herd within intensive regions, reducing profit impact associated with fertility.

Selection for growth via 600DW produced a positive response in all regions, albeit at lower levels than HP%. This was primarily due to the correlated response in Mature Cow Weight, whereby the benefits of larger and faster growing steers and heifers were partially offset by larger cows (see Table 3). Whilst selection for growth did produce favourable responses in sale weight, fewer animals were produced for sale due to the need to reduce and rebalance breeder numbers to accommodate correlated increases in cow size.

These results are consistent with the relative trait weightings applied to fertility and growth within selection indexes utilised by most key Northern Australian beef breeds. Most key selection indexes currently feature significantly greater selection weighting applied to fertility via the Days to Calving EBV.

However, the results highlight divergence in the economic responses to improved breeding cow fertility across extensive and intensive regions of Queensland. At a consistent level of selection intensity, economic benefits from improved fertility in extensive regions were estimated to be double the benefit of intensive regions. These results strongly suggest that herds operating within extensive regions of Northern Australia could benefit from increased emphasis on breeding cow fertility traits relative to herds in more intensive regions.

Limitations of the Analysis

The modelling process applied within this report focussed on selection for a single target trait whilst holding other traits constant. As previously described, the objective of this study was to explore responses to selection for fertility across a diverse range of Northern Australian beef enterprises and environments. Consequently, the results of this analysis should not be interpreted as estimating the potential benefits associated with genetic improvement in Northern Australia.

Care needs to be taken interpreting the results of this analysis as broadly advocating selection for specific traits within certain regions. The relative contribution of each trait will be influenced by a variety of enterprise-specific factors not contemplated within this analysis. Target markets and herd structure, breed type, property landtypes and management systems could all create different levels of response to those projected within this analysis. In addition, relative herd performance on a trait by trait basis will affect the response profile of each trait.

There is a considerable body of work highlighting variation in mortality rates, particularly of breeding females, across Northern Australian beef businesses (see Henderson *et al*. (2013), Holmes *et al.* (2017), McGowan *et al.* (2014)). McLean *et al*. (2014) identified variation in mortality rate as a key driver of variation in business performance.

Despite the importance of mortality rate as a driver of business performance, genetic contributions to mortality rate are largely unexplored. The authors hypothesise that traits analysed within this study could exhibit interactions with mortality rate. Selection for fertility traits could improve mortality rates through the preference for female phenotypes better suited to the Northern Australian environment as well as benefits associated with shorter inter-calving intervals and greater alignment to preferred seasonal calving patterns. Consequently, the ability to better understand interactions between key traits and mortality rate could affect the results reported within this analysis.

The analysis focused on genetic improvement via selection on a within breed basis, ignoring opportunities to generate improvement by changing cattle breed. There is considerable evidence that genetic variation exists both across and within breeds of cattle. Johnston *et al*. (2014) reported significant genotype differences in female reproduction traits between Tropical Composites and Brahmans (13% difference in lifetime annual weaning rate), whilst Wolcott et al. (2009) reported significant genotype differences for growth and carcass traits between the same breeds (8% difference in carcass weight at same slaughter age). Both studies involved head to head comparisons of each genotype on the same research stations and under the same management. Consequently, breed changes could deliver greater, and more rapid genetic improvement than within breed selection (where environment and market allow diversity in selected breed type).

The analysis represents a steady state comparison of the change in gross margin and EBIT of each trait. The response profile and transition timeline to full steady state benefit realisation are important factors in determining the economic benefit of selection via a net present value approach (NPV).

A simulation was undertaken for Region 311 to the length of time required to achieve a genetic standard deviation of improvement. Annual genetic progress for each trait was determined via the formula:

$$\Delta BV = (RBV \ \times i \ \times \ \sigma BV)/L$$

ΔBV is the annual rate of genetic progress, RBV is the accuracy of selection, i is the selection intensity, σBV is the genetic standard deviation and L is the generation interval (Bourdon, 2000).

In Region 311 L was calculated to be 5.37 years based on the age structure of the cow and bull herds within the baseline model. RBV was assumed to be 0.7 for growth traits (600DW), and 0.5 for HP%. σBV reflected the values reported in Table 1.

i was estimated to be 2.28 based on a p% of 2.9% (Oldenbroek and van der Waaij, 2015). p% represents the proportion of selected animals as a percentage of those available for selection. In the context of this exercise, this was difficult to estimate with the adopted p% reflecting within-herd selection of replacement bulls (33 new herd bulls each year from 1127 male calves).

As standard within northern commercial herds, it was assumed that replacement heifers were selected on phenotype and therefore RBV and i were adjusted to reflect that genetic progress was generated only through sire selections.

Based on the above it was estimated that a genetic standard deviation of improvement would take approximately 13.5 years for 600DW and 18.8 years for HP%.

Conclusion

Our analysis has demonstrated that selection for key traits, particularly female reproduction, can improve beef business profitability across a broad range of generic Queensland beef businesses. Our analysis, adopting a fixed grazing load in AE terms, has demonstrated the limited commercial benefit associated with selection for growth and size traits due to the need to carry fewer animals to accommodate the increased grazing load.

The analysis highlights the complex interactions between genotype, environment and management that shape the relative importance of individual traits. This highlights the need to equip purchasers of seedstock genetics with more specific and customisable tools and information to enable better understanding of the sire genetics that will most benefit their business.

Acknowledgements

The authors acknowledge the contribution of participants within the Northern Genomics Project that was the source of data within this project. In addition, the authors acknowledge the provision of funding from Meat & Livestock Australia for the Northern Genomics Project.

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Appendix 1: Detailed Results

Region	**R311**	**R311**	**R311**
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$1,165,009	$1,149,729	$1,204,890
Purchases	-$99,303	-$91,993	-$96,171
Inventory Change	$0	$0	$0
Gross Profit	**$1,065,707**	**$1,057,735**	**$1,108,719**
Animal Health	$24,474	$22,673	$24,975
Contracting & Mustering	$40,185	$40,185	$40,185
Fodder & Supplements	$123,648	$114,546	$122,355
Freight	$85,520	$80,304	$88,200
Insurance & Materials	$7,894	$7,313	$8,158
Selling Costs	$0	$0	$0
Direct Costs	**$281,722**	**$265,022**	**$283,872**
Gross Margin	**$783,985**	**$792,714**	**$824,847**
Overheads	**$424,517**	**$424,517**	**$424,517**
Total Op Ex	**$706,239**	**$689,539**	**$708,390**
EBIT	**$359,468**	**$368,196**	**$400,329**
PPE Assets	$8,320,000	$8,320,000	$8,320,000
Cattle	$3,498,490	$3,487,282	$3,433,128
Other Assets	$115,000	$115,000	$115,000
Total Assets	**$11,933,490**	**$11,922,282**	**$11,868,128**
ROA	**3.0%**	**3.1%**	**3.4%**
AE Carried	**6513**	**6513**	**6513**
Cattle Carried	6974	6461	6905
Cattle Sold	1976	1830	2053
Breeders Mated	4138	3833	4007
Calves Weaned	2255	2089	2331
Weaning %	54.5%	54.5%	58.2%
Mortalities	280	259	278
Mortality Rate	4.0%	4.0%	4.0%
Average Sale Value	$590	$628	$587
Average Sale Weight	340	363	335
Average Sale Price	$1.74	$1.73	$1.75
KG Produced	649,358	643,496	667,332
Gross Profit per KG	$1.64	$1.64	$1.66
COP	$1.09	$1.07	$1.06
KG per AE	99.7	98.8	102.5

Region	R312	R312	R312
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$896,387	$889,065	$921,503
Purchases	-$76,175	-$71,614	-$73,374
Inventory Change	$0	$0	$0
Gross Profit	**$820,212**	**$817,451**	**$848,129**
Animal Health	$38,086	$35,804	$37,728
Contracting & Mustering	$29,052	$29,052	$29,052
Fodder & Supplements	$50,676	$47,641	$50,157
Freight	$92,013	$88,169	$94,856
Insurance & Materials	$7,812	$7,345	$8,083
Selling Costs	$0	$0	$0
Direct Costs	**$217,639**	**$208,011**	**$219,876**
Gross Margin	**$602,573**	**$609,440**	**$628,253**
Overheads	**$400,191**	**$400,191**	**$400,191**
Total Op Ex	**$617,830**	**$608,203**	**$620,068**
EBIT	**$202,381**	**$209,248**	**$228,061**
PPE Assets	$9,167,000	$9,167,000	$9,167,000
Cattle	$2,194,381	$2,185,306	$2,156,093
Other Assets	$152,000	$152,000	$152,000
Total Assets	**$11,513,381**	**$11,504,306**	**$11,475,093**
ROA	**1.8%**	**1.8%**	**2.0%**
AE Carried	**4842**	**4842**	**4842**
Cattle Carried	4074	3830	4042
Cattle Sold	1460	1372	1515
Breeders Mated	2176	2046	2096
Calves Weaned	1594	1499	1650
Weaning %	73.3%	73.3%	78.7%
Mortalities	134	126	134
Mortality Rate	3.3%	3.3%	3.3%
Average Sale Value	$614	$648	$608
Average Sale Weight	349	368	343
Average Sale Price	$1.76	$1.76	$1.77
KG Produced	499,144	496,038	509,719
Gross Profit per KG	$1.64	$1.65	$1.66
COP	$1.24	$1.23	$1.22
KG per AE	103.1	102.4	105.3

Region	R313	R313	R313
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$601,678	$599,533	$612,399
Purchases	-$45,485	-$42,533	-$44,326
Inventory Change	$0	$0	$0
Gross Profit	**$556,193**	**$556,999**	**$568,073**
Animal Health	$3,944	$3,688	$3,914
Contracting & Mustering	$16,487	$16,487	$16,487
Fodder & Supplements	$110,468	$103,302	$110,280
Freight	$38,696	$36,805	$39,507
Insurance & Materials	$4,364	$4,080	$4,496
Selling Costs	$0	$0	$0
Direct Costs	**$173,959**	**$164,364**	**$174,684**
Gross Margin	**$382,234**	**$392,635**	**$393,389**
Overheads	**$331,116**	**$331,116**	**$331,116**
Total Op Ex	**$505,075**	**$495,480**	**$505,800**
EBIT	**$51,118**	**$61,520**	**$62,273**
PPE Assets	$6,901,000	$6,901,000	$6,901,000
Cattle	$1,801,734	$1,804,925	$1,787,632
Other Assets	$258,000	$258,000	$258,000
Total Assets	**$8,960,734**	**$8,963,925**	**$8,946,632**
ROA	**0.6%**	**0.7%**	**0.7%**
AE Carried	**3705**	**3705**	**3705**
Cattle Carried	3489	3263	3471
Cattle Sold	1091	1020	1124
Breeders Mated	1895	1772	1847
Calves Weaned	1200	1122	1232
Weaning %	63.3%	63.3%	66.7%
Mortalities	109	102	108
Mortality Rate	3.1%	3.1%	3.1%
Average Sale Value	$552	$588	$545
Average Sale Weight	317	338	310
Average Sale Price	$1.74	$1.74	$1.76
KG Produced	335,779	335,717	339,122
Gross Profit per KG	$1.66	$1.66	$1.68
COP	$1.50	$1.48	$1.49
KG per AE	90.6	90.6	91.5

Region	R314	R314	R314
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$427,731	$424,512	$434,248
Purchases	-$64,543	-$60,965	-$61,901
Inventory Change	$0	$0	$0
Gross Profit	**$363,188**	**$363,547**	**$372,346**
Animal Health	$18,836	$17,787	$19,039
Contracting & Mustering	$10,746	$10,746	$10,746
Fodder & Supplements	$22,261	$21,027	$22,250
Freight	$36,956	$35,932	$37,576
Insurance & Materials	$3,312	$3,129	$3,395
Selling Costs	$0	$0	$0
Direct Costs	**$92,111**	**$88,620**	**$93,006**
Gross Margin	**$271,077**	**$274,926**	**$279,341**
Overheads	**$279,388**	**$279,388**	**$279,388**
Total Op Ex	**$371,499**	**$368,009**	**$372,394**
EBIT	**-$8,311**	**-$4,462**	**-$48**
PPE Assets	$5,805,000	$5,805,000	$5,805,000
Cattle	$1,045,406	$1,037,407	$1,036,971
Other Assets	$158,000	$158,000	$158,000
Total Assets	**$7,008,406**	**$7,000,407**	**$6,999,971**
ROA	**-0.1%**	**-0.1%**	**0.0%**
AE Carried	**2107**	**2107**	**2107**
Cattle Carried	1765	1667	1759
Cattle Sold	627	592	643
Breeders Mated	861	813	825
Calves Weaned	662	626	679
Weaning %	77.0%	77.0%	82.3%
Mortalities	35	33	36
Mortality Rate	2.0%	2.0%	2.0%
Average Sale Value	$682	$717	$675
Average Sale Weight	396	416	389
Average Sale Price	$1.72	$1.72	$1.74
KG Produced	242,552	241,208	244,694
Gross Profit per KG	$1.50	$1.51	$1.52
COP	$1.53	$1.53	$1.52
KG per AE	115.1	114.5	116.1

Region	R322	R322	R322
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$398,589	$395,671	$406,121
Purchases	-$28,127	-$26,805	-$27,858
Inventory Change	$0	$0	$0
Gross Profit	**$370,462**	**$368,866**	**$378,263**
Animal Health	$10,138	$9,662	$10,209
Contracting & Mustering	$7,169	$7,169	$7,169
Fodder & Supplements	$26,709	$25,453	$26,945
Freight	$19,491	$18,867	$21,142
Insurance & Materials	$1,767	$1,684	$1,864
Selling Costs	$0	$0	$0
Direct Costs	**$65,273**	**$62,834**	**$67,328**
Gross Margin	**$305,189**	**$306,032**	**$310,935**
Overheads	**$255,679**	**$255,679**	**$255,679**
Total Op Ex	**$320,952**	**$318,513**	**$323,007**
EBIT	**$49,510**	**$50,353**	**$55,256**
PPE Assets	$6,316,000	$6,316,000	$6,316,000
Cattle	$851,678	$847,969	$855,015
Other Assets	$162,000	$162,000	$162,000
Total Assets	**$7,329,678**	**$7,325,969**	**$7,333,015**
ROA	**0.7%**	**0.7%**	**0.8%**
AE Carried	**1757**	**1757**	**1757**
Cattle Carried	1127	1074	1118
Cattle Sold	485	463	513
Breeders Mated	625	596	619
Calves Weaned	505	481	532
Weaning %	80.8%	80.8%	86.0%
Mortalities	19	19	19
Mortality Rate	1.7%	1.7%	1.7%
Average Sale Value	$821	$855	$791
Average Sale Weight	417	435	397
Average Sale Price	$1.97	$1.97	$1.99
KG Produced	200,001	198,827	201,418
Gross Profit per KG	$1.85	$1.86	$1.88
COP	$1.60	$1.60	$1.60
KG per AE	113.8	113.2	114.6

Region	R331	R331	R331
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$247,258	$244,932	$249,995
Purchases	-$22,632	-$21,291	-$22,122
Inventory Change	$0	$0	$0
Gross Profit	**$224,626**	**$223,642**	**$227,873**
Animal Health	$8,388	$7,891	$8,328
Contracting & Mustering	$4,196	$4,196	$4,196
Fodder & Supplements	$28,341	$26,664	$28,326
Freight	$10,456	$10,006	$10,962
Insurance & Materials	$1,259	$1,184	$1,286
Selling Costs	$0	$0	$0
Direct Costs	**$52,640**	**$49,942**	**$53,098**
Gross Margin	**$171,986**	**$173,700**	**$174,775**
Overheads	**$199,932**	**$199,932**	**$199,932**
Total Op Ex	**$252,572**	**$249,874**	**$253,029**
EBIT	**-$27,946**	**-$26,232**	**-$25,156**
PPE Assets	$5,050,000	$5,050,000	$5,050,000
Cattle	$671,149	$665,521	$667,242
Other Assets	$108,000	$108,000	$108,000
Total Assets	**$5,829,149**	**$5,823,521**	**$5,825,242**
ROA	**-0.5%**	**-0.5%**	**-0.4%**
AE Carried	**1119**	**1119**	**1119**
Cattle Carried	976	918	972
Cattle Sold	343	322	350
Breeders Mated	503	473	492
Calves Weaned	360	338	367
Weaning %	71.5%	71.5%	74.7%
Mortalities	17	16	17
Mortality Rate	1.8%	1.8%	1.8%
Average Sale Value	$722	$760	$714
Average Sale Weight	372	392	365
Average Sale Price	$1.94	$1.94	$1.95
KG Produced	125,367	124,453	126,058
Gross Profit per KG	$1.79	$1.80	$1.81
COP	$2.01	$2.01	$2.01
KG per AE	112.0	111.2	112.7

Region	**R332**	**R332**	**R332**
Trait	**Baseline**	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$205,827	$204,906	$209,589
Purchases	-$25,145	-$23,273	-$24,088
Inventory Change	$0	$0	$0
Gross Profit	**$180,682**	**$181,634**	**$185,501**
Animal Health	$5,610	$5,193	$5,701
Contracting & Mustering	$5,352	$5,352	$5,352
Fodder & Supplements	$20,713	$19,171	$20,857
Freight	$9,868	$9,375	$10,111
Insurance & Materials	$1,654	$1,531	$1,703
Selling Costs	$0	$0	$0
Direct Costs	**$43,197**	**$40,621**	**$43,724**
Gross Margin	**$137,485**	**$141,012**	**$141,776**
Overheads	**$193,102**	**$193,102**	**$193,102**
Total Op Ex	**$236,299**	**$233,724**	**$236,827**
EBIT	**-$55,617**	**-$52,090**	**-$51,326**
PPE Assets	$4,317,000	$4,317,000	$4,317,000
Cattle	$583,324	$578,904	$578,324
Other Assets	$256,000	$256,000	$256,000
Total Assets	**$5,156,324**	**$5,151,904**	**$5,151,324**
ROA	**-1.1%**	**-1.0%**	**-1.0%**
AE Carried	**1108**	**1108**	**1108**
Cattle Carried	1131	1047	1124
Cattle Sold	318	295	328
Breeders Mated	503	465	482
Calves Weaned	338	312	348
Weaning %	67.1%	67.1%	72.2%
Mortalities	19	18	19
Mortality Rate	1.7%	1.7%	1.7%
Average Sale Value	$647	$696	$638
Average Sale Weight	389	419	380
Average Sale Price	$1.66	$1.66	$1.68
KG Produced	120,468	120,367	121,678
Gross Profit per KG	$1.50	$1.51	$1.52
COP	$1.96	$1.94	$1.95
KG per AE	108.7	108.6	109.8

Appendix 2: Results per AE

	R311	R311	R311
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$178.87	$176.53	$185.00
Purchases	-$15.25	-$14.12	-$14.77
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$163.63**	**$162.40**	**$170.23**
Animal Health	$3.76	$3.48	$3.83
Contracting & Mustering	$6.17	$6.17	$6.17
Fodder & Supplements	$18.98	$17.59	$18.79
Freight	$13.13	$12.33	$13.54
Insurance & Materials	$1.21	$1.12	$1.25
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$43.26**	**$40.69**	**$43.59**
Gross Margin	**$120.37**	**$121.71**	**$126.65**
Overheads	**$65.18**	**$65.18**	**$65.18**
Total Op Ex	**$108.44**	**$105.87**	**$108.77**
EBIT	**$55.19**	**$56.53**	**$61.47**
PPE Assets	$1,277.45	$1,277.45	$1,277.45
Cattle	$537.15	$535.43	$527.12
Other Assets	$17.66	$17.66	$17.66
Total Assets	**$1,832**	**$1,831**	**$1,822**

	R312	R312	R312
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$185.13	$183.62	$190.31
Purchases	-$15.73	-$14.79	-$15.15
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$169.40**	**$168.83**	**$175.16**
Animal Health	$7.87	$7.39	$7.79
Contracting & Mustering	$6.00	$6.00	$6.00
Fodder & Supplements	$10.47	$9.84	$10.36
Freight	$19.00	$18.21	$19.59
Insurance & Materials	$1.61	$1.52	$1.67
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$44.95**	**$42.96**	**$45.41**
Gross Margin	**$124.45**	**$125.87**	**$129.75**
Overheads	**$82.65**	**$82.65**	**$82.65**
Total Op Ex	**$127.60**	**$125.61**	**$128.06**
EBIT	**$41.80**	**$43.22**	**$47.10**
PPE Assets	$1,893.23	$1,893.23	$1,893.23
Cattle	$453.20	$451.32	$445.29
Other Assets	$31.39	$31.39	$31.39
Total Assets	**$2,378**	**$2,376**	**$2,370**

	R313	R313	R313
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$162.40	$161.82	$165.29
Purchases	-$12.28	-$11.48	-$11.96
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$150.12**	**$150.34**	**$153.33**
Animal Health	$1.06	$1.00	$1.06
Contracting & Mustering	$4.45	$4.45	$4.45
Fodder & Supplements	$29.82	$27.88	$29.77
Freight	$10.44	$9.93	$10.66
Insurance & Materials	$1.18	$1.10	$1.21
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$46.95**	**$44.36**	**$47.15**
Gross Margin	**$103.17**	**$105.97**	**$106.18**
Overheads	**$89.37**	**$89.37**	**$89.37**
Total Op Ex	**$136.32**	**$133.73**	**$136.52**
EBIT	**$13.80**	**$16.60**	**$16.81**
PPE Assets	$1,862.62	$1,862.62	$1,862.62
Cattle	$486.30	$487.16	$482.49
Other Assets	$69.64	$69.64	$69.64
Total Assets	**$2,419**	**$2,419**	**$2,415**

	R314	R314	R314
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$203.00	$201.48	$206.10
Purchases	-$30.63	-$28.93	-$29.38
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$172.37**	**$172.54**	**$176.72**
Animal Health	$8.94	$8.44	$9.04
Contracting & Mustering	$5.10	$5.10	$5.10
Fodder & Supplements	$10.57	$9.98	$10.56
Freight	$17.54	$17.05	$17.83
Insurance & Materials	$1.57	$1.48	$1.61
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$43.72**	**$42.06**	**$44.14**
Gross Margin	**$128.66**	**$130.48**	**$132.58**
Overheads	**$132.60**	**$132.60**	**$132.60**
Total Op Ex	**$176.32**	**$174.66**	**$176.74**
EBIT	**-$3.94**	**-$2.12**	**-$0.02**
PPE Assets	$2,755.10	$2,755.10	$2,755.10
Cattle	$496.16	$492.36	$492.16
Other Assets	$74.99	$74.99	$74.99
Total Assets	**$3,326**	**$3,322**	**$3,322**

	R322	R322	R322
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$226.86	$225.20	$231.14
Purchases	-$16.01	-$15.26	-$15.86
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$210.85**	**$209.94**	**$215.29**
Animal Health	$5.77	$5.50	$5.81
Contracting & Mustering	$4.08	$4.08	$4.08
Fodder & Supplements	$15.20	$14.49	$15.34
Freight	$11.09	$10.74	$12.03
Insurance & Materials	$1.01	$0.96	$1.06
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$37.15**	**$35.76**	**$38.32**
Gross Margin	**$173.70**	**$174.18**	**$176.97**
Overheads	**$145.52**	**$145.52**	**$145.52**
Total Op Ex	**$182.67**	**$181.28**	**$183.84**
EBIT	**$28.18**	**$28.66**	**$31.45**
PPE Assets	$3,594.76	$3,594.76	$3,594.76
Cattle	$484.73	$482.62	$486.63
Other Assets	$92.20	$92.20	$92.20
Total Assets	**$4,172**	**$4,170**	**$4,174**

	R331	R331	R331
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$220.96	$218.89	$223.41
Purchases	-$20.23	-$19.03	-$19.77
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$200.74**	**$199.86**	**$203.64**
Animal Health	$7.50	$7.05	$7.44
Contracting & Mustering	$3.75	$3.75	$3.75
Fodder & Supplements	$25.33	$23.83	$25.31
Freight	$9.34	$8.94	$9.80
Insurance & Materials	$1.13	$1.06	$1.15
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$47.04**	**$44.63**	**$47.45**
Gross Margin	**$153.70**	**$155.23**	**$156.19**
Overheads	**$178.67**	**$178.67**	**$178.67**
Total Op Ex	**$225.71**	**$223.30**	**$226.12**
EBIT	**-$24.97**	**-$23.44**	**-$22.48**
PPE Assets	$4,512.96	$4,512.96	$4,512.96
Cattle	$599.78	$594.75	$596.28
Other Assets	$96.51	$96.51	$96.51
Total Assets	**$5,209**	**$5,204**	**$5,206**

	R332	R332	R332
	Baseline	**600 Day Weight**	**Heifer Pregnancy Rate**
Gross Sales	$185.76	$184.93	$189.16
Purchases	-$22.69	-$21.00	-$21.74
Inventory Change	$0.00	$0.00	$0.00
Gross Profit	**$163.07**	**$163.93**	**$167.42**
Animal Health	$5.06	$4.69	$5.15
Contracting & Mustering	$4.83	$4.83	$4.83
Fodder & Supplements	$18.69	$17.30	$18.82
Freight	$8.91	$8.46	$9.13
Insurance & Materials	$1.49	$1.38	$1.54
Selling Costs	$0.00	$0.00	$0.00
Direct Costs	**$38.99**	**$36.66**	**$39.46**
Gross Margin	**$124.08**	**$127.27**	**$127.96**
Overheads	**$174.28**	**$174.28**	**$174.28**
Total Op Ex	**$213.27**	**$210.94**	**$213.74**
EBIT	**-$50.20**	**-$47.01**	**-$46.32**
PPE Assets	$3,896.21	$3,896.21	$3,896.21
Cattle	$526.47	$522.48	$521.95
Other Assets	$231.05	$231.05	$231.05
Total Assets	**$4,654**	**$4,650**	**$4,649**