Department of Agriculture and Fisheries

Desktop research project to provide data on liveweight and liveweight gain in the beef cattle sector in Queensland and the Northern Territory

Steven Bray, Dionne Walsh, Madonna Hoffmann, Beverley Henry, Sandra Eady, Casey Collier, Caroline Pettit, Javi Navarro, Debra Corbet

FINAL REPORT

2015

Northern Territory Government

CSIRO

Queensland Government

How to cite this report:

Bray S, Walsh D, Hoffmann M, Henry B, Eady S, Collier C, Pettit C, Navarro J and Corbet D (2015) Desktop research project to provide data on liveweight and liveweight gain in the beef cattle sector in Queensland and the Northern Territory. Department of Agriculture and Fisheries. Rockhampton, Queensland.

Contents

Executive summary

At the national scale, north Australian beef livestock emissions are calculated using regional statistically sampled livestock numbers and reference tables for liveweight (LW) and liveweight gain (LWG). These figures are used to estimate livestock dry matter intake (DMI) and subsequently enteric methane emissions. Reference tables for feed dry matter digestibility (DMD) and crude protein (CP) are used to estimate nitrous oxide emissions. The most recent Australian National Greenhouse Accounts: National Inventory Report (NIR) includes reference tables of LW and LWG for seven classes of cattle in four seasons for nine regions across Australia. The regions are generally defined by state and territory borders. Given the significant variation in rainfall (300-2000 mm) and soil fertility across Queensland and the Northern Territory, the state- and territory-wide reference figures are unlikely to adequately represent the majority of cattle herds.

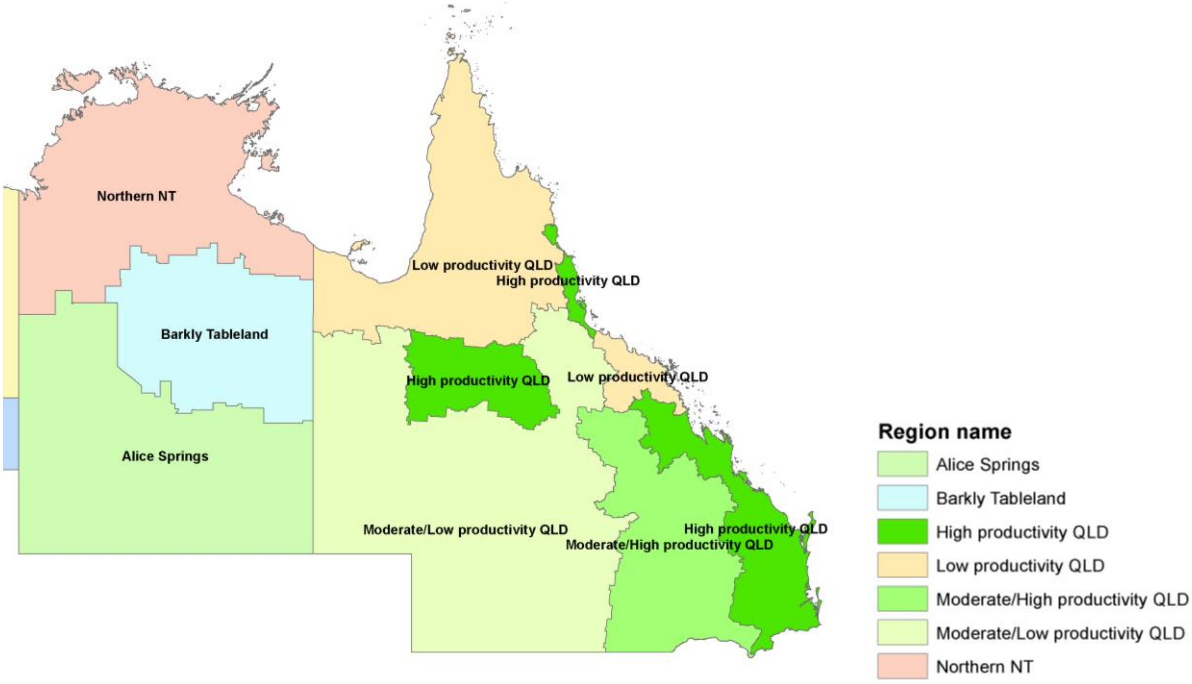
At the individual beef business scale, productivity growth and returns on investment in the northern Australian beef industry are generally static or declining and, together with high debt levels and increasing input costs, many northern grazing businesses are in a dire financial situation. Additional ‘carbon income’ may be available to some grazing businesses through participation in the Australian Government’s Emissions Reduction Fund (ERF). The lack of representative LW and LWG data may hinder the development and/or application of ERF methodologies, which would enable grazing businesses to successfully diversify their income stream. ERF project livestock emission reductions must be consistent with the National Greenhouse Accounts.

This project collated experimental data on beef cattle LW and LWG in Queensland and the Northern Territory from published and unpublished sources. Data sources included regularly weighed experiments, occasionally weighed trials and demonstrations and producer/professional verified property herd models primarily using Breedcow Dynama software. Over 7500 LW records were collated from 4348 mobs, 2196 herds and 134 data sources in Queensland and the Northern Territory. Over 4500 pasture quality records for DMD and CP in Queensland and the Northern Territory have also been collated. The proportion of cattle numbers in each class and the number of cows lactating were also derived for each region.

The experimental data were compared to the Australian National Greenhouse Accounts: National Inventory Report (DIICCSRTE 2013) reference data on seasonal LW, LWG, DMD and CP data for Queensland and the Northern Territory, as well as seasonal LW and LWG data derived from representative Breedcow Dynama herd models for 12 sub-regions in Queensland and four sub-regions in the Northern Territory. Together with mapped biophysical data and Australian Bureau of Statistics (ABS) SA2 regional boundaries, the data comparisons were used to nominate and justify appropriate new sub-regions and livestock classes, and generate reference tables in Queensland and the Northern Territory for Australian Greenhouse Accounts and ERF methodology purposes.

Recommendations

To meet the requirements for national inventory reporting, we have worked to ensure that the recommended regionalisation aligns with national statistical sampling boundaries (i.e. ABS SA2 regions for cattle numbers). Based on our examination of the data and biophysical parameters, we recommend three subregions for the Northern Territory: Alice Springs, Barkly Tableland and Northern NT (the latter combining the Victoria River District, Sturt Plateau, Top End and NT Gulf regions). In Queensland there was little clear separation of regions but rather a continuum of productivity. We thus recommend that Queensland be divided into four regional groups: High, Moderate/High, Moderate/Low and Low productivity. The High productivity LW and LWG regions (representing 29% of the Queensland cattle herd) were generally associated with high soil fertility and higher rainfall (e.g. Darling Downs, Wet Coast and Tableland), whilst the Low LW and LWG regions (representing 16% of the herd) were generally associated with infertile soils and a strongly monsoonal climate with poor pasture quality for much of the year (e.g. Cape York and Queensland Gulf - Burke and Carpentaria). The Moderate/High LW and LWG region was associated with the Brigalow region of central and southern sub-coastal Queensland (representing 31% of the herd). This region contains a mix of fertile productive land types interspersed with low fertility land types. The Moderate/Low LW and LWG region (representing 24% of the herd) contains more arid, but relatively fertile regions (e.g. West and SW Queensland) and the moderate to low fertility Goldfields region west of Townsville.



Map 1: Map of proposed regions in Queensland and the Northern Territory

Whilst the recommended regions align with ABS SA2 statistical boundaries for NIR purposes, further consideration may be required when using the reference tables for district- or property-level ERF purposes. At the district or property scale there will be a range of land types from good productivity (e.g. fertile alluvial flats) to poor (e.g. phosphorus deficient stony hills). Due to the productivity continuum across northern Australia, we recommend that scope be given to ensure that a particular district or property is able to align with appropriate regional reference tables and benchmarks, based on its relative productivity for ERF project purposes.

After examining the LW data for regions across Queensland and the Northern Territory and combined with knowledge of the production systems in those regions and the relative numbers of cattle in those classes, we recommend 10 livestock classes for Australian Greenhouse Accounts and ERF methodology purposes; two classes for bulls (less than or greater than 1 year), four classes for females (up to 3+ years) and four classes for steers (up to 3+ years). This is three more classes than the current NIR and three less classes than derived by CSIRO (Havard *et al.* 2013). Ten livestock classes provides a balance between having an excessive number of beef livestock classes on which to collect national data for NIR and other purposes, and being able to accommodate livestock management strategies implemented for ERF purposes.

Although time consuming and requiring considerable expert interpretation, this beef cattle LW and LWG data compilation process has provided a comprehensive reference dataset to compare to regional herd models. The dataset will be useful for other beef cattle productivity, profitability and sustainability research, development and extension activities.

Introduction

Background

At the national scale, northern Australian beef livestock emissions are calculated using regional statistically sampled livestock numbers (total and feedlot numbers) and NIR (National Inventory Report) reference tables for liveweight (LW) and liveweight gain (LWG). These figures are used to estimate livestock dry matter intake (DMI) and subsequently enteric methane emissions. NIR reference tables for feed dry matter digestibility (DMD) and crude protein (CP) are used to estimate nitrous oxide emissions.

At the individual beef business scale, productivity growth and returns on investment in the north Australian beef industry are generally static or declining and together with high debt levels and increasing input costs, many northern grazing businesses are in a dire financial situation (McLean *et al.* 2014). Additional 'carbon income' may be available to some grazing businesses through participation in the Australian Government's Emissions Reduction Fund (ERF). However, the lack of representative LW and LWG data may hinder the development ERF methodologies, which would enable grazing businesses to successfully diversify their income stream. ERF project livestock emission reductions must be consistent with the National Greenhouse Accounts. The lack of a more precise regional breakdown of LW and LWG means that proponents in some states/territories seeking to use an ERF methodology have been required to collect LW data on-farm rather than use the default values in the NIR reference tables.

The most recent Australian National Greenhouse Accounts: National Inventory Report (DIICCSRTE 2013) includes reference tables for LW and LWG. These tables cover LW and LWG for seven classes of cattle in four seasons for nine regions across Australia. The regions are defined by state and territory borders. Currently, the only state that is divided into sub-regions is Western Australia. Importantly, the significant beef cattle jurisdictions of Queensland and the Northern Territory (51% of the national herd; Queensland 11.4 million head, Northern Territory 2.1 million head) assume one value for LW and LWG for each livestock class. Given the significant variation in rainfall (300-2000 mm), soil fertility and productivity across Queensland and the Northern Territory, the state- and territory-wide reference figures are unlikely to adequately represent the majority of cattle herds. Furthermore, the National Greenhouse Accounts: National Inventory Report uses an assumption that cattle herds have relatively high LWG and calve in the spring season in Queensland. This is generally not the case across most of northern Australia. Typically, the spring season has the poorest pasture quality and liveweight gain, and most cattle calve in the late spring/early summer and lactate through summer to coincide with the annual wet season. The lack of representative LW and LWG data creates issues with the calculation of greenhouse gas emissions from cattle and makes comparisons of management change and regions difficult and uncertain.

Aim of this research project

The aim of this research project was to address the issues raised above by:

1. reviewing and refining the representative herd model data on LW and LWG provided by Dr Sandra Eady of CSIRO based on the project 'A method to refine the geographical scale of greenhouse gas emissions for the Northern Beef Industry' (Havard *et al.* 2013)
2. collating and referencing experimental data on beef cattle LW, LWG and pasture quality (CP and DMD) in Queensland and the Northern Territory and summarising these using the categories in the National Inventory Report
3. using the collated data on LW, LWG and pasture quality (CP and DMD) in Queensland and the Northern Territory to propose and justify new state/territory sub-region boundaries aligned to ABS SA2 boundaries (with a target maximum of 4-5 sub-regions in the NT and 5-6 sub-regions in Queensland).
4. Using regionally representative herd structure models to derive the proportion of cattle numbers in each class and the proportion of cows lactating.

Review of current data

The most recent Australian National Greenhouse Accounts NIR reference tables for LW and LWG cover seven classes of cattle in four seasons for nine regions across Australia (Tables 6.B.1 and 6.B.2 in DIICCSRTE 2013). Regions are defined by state and territory borders. Figure 1 depicts predictions of LW from the current inventory tables over the life of female, steer and bull beef cattle in Queensland and the Northern Territory.

One of the limitations of this inventory data for northern Australia is the limited number of livestock classes. Cattle in northern Australia generally have slower growth rates and take three to four years to reach mature size. Therefore, a livestock class of Steers >1 contains livestock with a wide range of weights as steers in some regions are generally not sold until 2.5-3.5 years of age. Similarly, the Cows >2 class contains 2-year-old heifers which are likely to have a much lower weight than mature cows. In the case of bulls, the Bulls >1 class currently contains everything from 250 kg weaner bulls to 800 kg >4-year-old bulls which manifests as a large spike in average LW between 1 and 1.25 years of age (Figure 1).

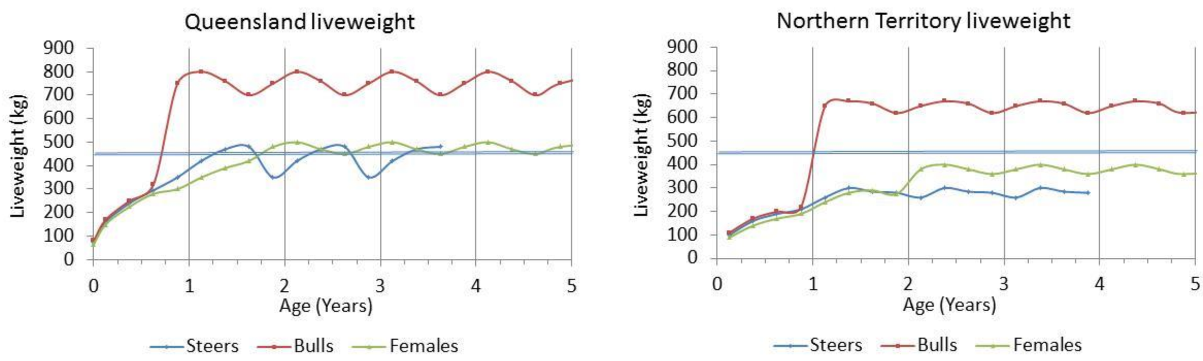


Figure 1: Liveweight data predictions over the life of female, steer and bull beef cattle in Queensland and the Northern Territory from the current national inventory reference tables. Data for Cows >2, Steers >1 and Bulls >1 years of age are repeated annually (Source: Tables 6.B.1 and 6.B.2 (DIICCSRTE 2013)). The blue 450 kg adult equivalent (AE) line is included on the graph as a comparative reference.

To address these issues, CSIRO (Havard *et al.* 2013) recommended expanding the number of livestock classes from 7 to 13 and increased the number of regions in Queensland to 12 and in the Northern Territory to 4 (Table 1; Figure 2). The study used the representative Breedcow Dynama herd models for northern Australian regions generated during the Beef CRC (DAF 2015). These representative herd models were originally developed using an experiential process accessing animal production experts in the regions. Unfortunately, the data and information used to inform the model parameters (e.g. experimental trials, property consultations) were not recorded or referenced adequately at that time. This project been able to partly redress this oversight by comparing the model LW parameters to experimental data.

The Beef CRC Breedcow Dynama representative herd models (DAF 2015) are based on ABARES statistical regions and major land types within some ABARES statistical regions. These regional boundaries differ from ABS SA2 regions, which are used to collect livestock numbers for the Australian National Greenhouse Accounts. There are 525 SA2 regions in Queensland and 67 SA2 regions in the Northern Territory based on a human population of approximately 10,000 people. This means that individual SA2 regions are large in less populated remote areas (e.g. western Queensland) and small in heavily populated areas. As part of on-going project work, CSIRO (Eady & Navarro, unpublished) matched the Beef CRC Breedcow Dynama representative herd model regions to amalgamated ABS SA2 regions using ABARES regional boundaries and similarity between herd models. This resulted in 12 sub-regions in Queensland and 4 sub-regions in the Northern Territory (Figure 2, Appendix 1).

Table 1: Comparison of livestock classes in the National Inventory Report reference tables, CSIRO (Havard *et al*. 2013) and proposed in this report.

	NIR reference tables	CSIRO	Proposed (this report)
Female Classes	Cows<1 Cows 1 to 2 Cows>2	Heifer calves 0-1 year old Heifers 1-2 years Heifers 2-3 years Cows 3-4 years Cows 4+ years Spayed cows	Heifer calves 0-1 year old Heifers 1-2 years Heifers 2-3 years Cows 3+ years
Steer Classes	Steers<1 Steers>1	Steer calves 0-1 year old Steers 1-2 years Steers 2-3 years Steers 3-4 years Steers 4+ years	Steer calves 0-1 year old Steers 1-2 years Steers 2-3 years Steers 3+ years
Bull Classes	Bulls<1 Bulls>1	Bull calves 0-1 year old Bulls 1 year and older	Bull calves 0-1 year old Bulls 1+ years

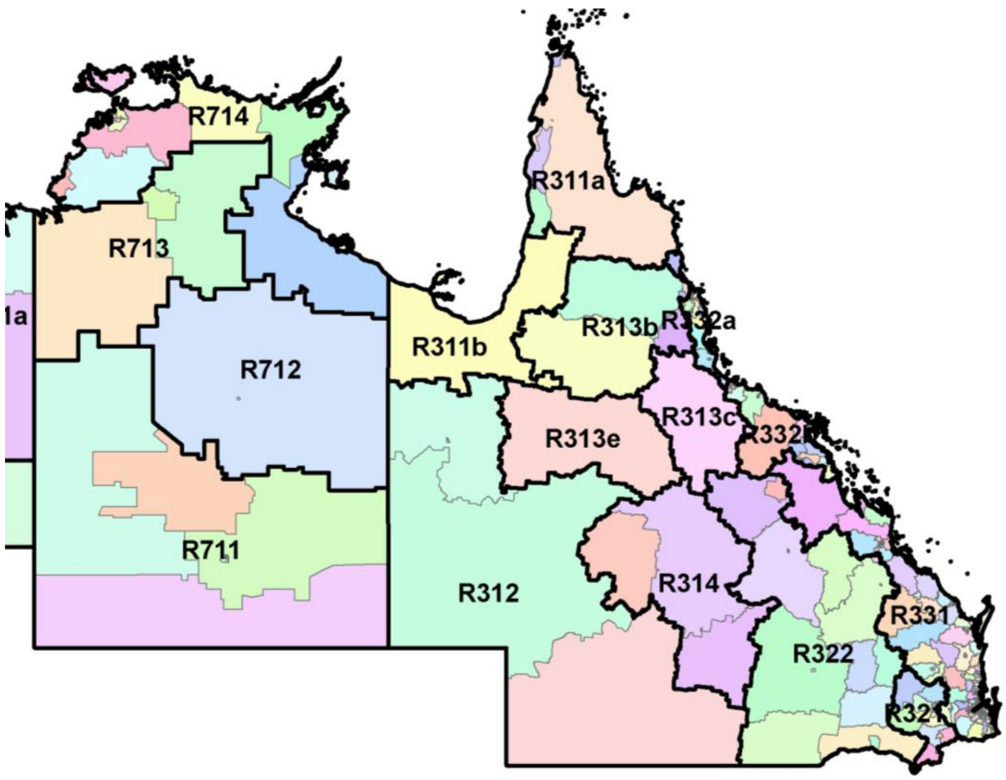


Figure 2: Regional boundaries (black) based on Breedcow Dynama representative herd model regions and Australian Bureau of Statistics SA2 boundaries (Eady and Navarro, unpublished).

The regionalisation and livestock class work of CSIRO (Havard *et al*. 2013; Eady and Navarro, unpublished), the NIR tables (DIICCSRTE 2013) and comparison to livestock and pasture quality datasets collated as part of this project formed the basis for further refinement and justification of sub-regions and selection of livestock classes.

Methods

Regional seasonal LW and LWG data were extracted from the Beef CRC Breedcow Dynama templates (Havard *et al*. 2013) and state-wide NIR reference table seasonal LW, LWG, DMD and CP data from DIICCSRTE (2013) (Tables 6.B.1, 6.B.2, 6.B.3 and 6.B.4).

Experimental data on beef cattle LW and LWG and pasture data on DMD and CP in Queensland and the Northern Territory were obtained from published and unpublished sources (typically these sources were the experiment leaders). Unpublished sources were required because the published summarised data was typically too coarse to extract seasonal and livestock class data. Data was collated from a range of sources including regularly weighed experiments, occasionally weighed trials and demonstrations and producer/professional verified property herd models primarily using Breedcow Dynama software. Seasonal LW and LWG gain data for each livestock class was extracted from Breedcow Dynama models using the methodology of Havard *et al*. (2013). The herd structure in the regional Breedcow Dynama models was also used to estimate the proportion of cattle in each livestock class and the proportion of cows lactating.

Pasture quality data DMD and CP was faecal near-infra-red spectroscopy (F.NIRS) data from the analysis of livestock manure samples. F.NIRS data has advantages over chemical analysis of harvested pasture samples as it accounts for diet selection by livestock.

The Beef CRC Breedcow Dynama templates, NIR and experimental data were compared and contrasted (together with regional biophysical attributes) to determine if improvements could be identified in sub-regionalisation for Australian Greenhouse Accounts and ERF methodology purposes.

Relational database development and data entry

An enhanced entity relationship model was developed using an iterative process based on prototype models and analysis of some example cattle LW datasets. The enhanced entity relationship model led to determining the relational data model, enhanced relationship mapping and integrity constraints (Figure 3). The database was normalised to the fifth normal form and the physical design was developed in MS Access.

The experimental LW data and key information on trial and property name, GPS location, NIR region, livestock class and weigh date were collated into a MS Excel template which was subsequently imported into the database using queries to manipulate and check data integrity. It was observed that stricter formatting and constraints within the template should be applied in future to ensure a greater consistency, as the data form varied between different data sources.

Data outputs

SQLs (database queries) were developed to extract regional monthly and seasonal LW outputs. The efficiency and effectiveness of the database has improved and could be improved further with some small changes to entity attributes. Extraction of different outputs from the database highlighted issues which have needed to be addressed during the project using an iterative process.

For each dataset, the GPS location was used to allocate a SA2 regional group (Figure 2; Appendix 1). Datasets from regional representative Breedcow Dynama herd models were allocated a centroid GPS location for the region. Average seasonal and monthly LW (for females, steers and bulls), data count and standard deviation (SD) for the whole of Queensland, whole of the Northern Territory and the SA2 regional groups were extracted from the database. Seasonal liveweight data and standard deviation for females, steers and bulls were subsequently graphed for each region for comparison.

Following analysis to justify the amalgamation of regions (see methods below), average seasonal LW, pasture DMD and CP data were extracted for the proposed new sub-regions.

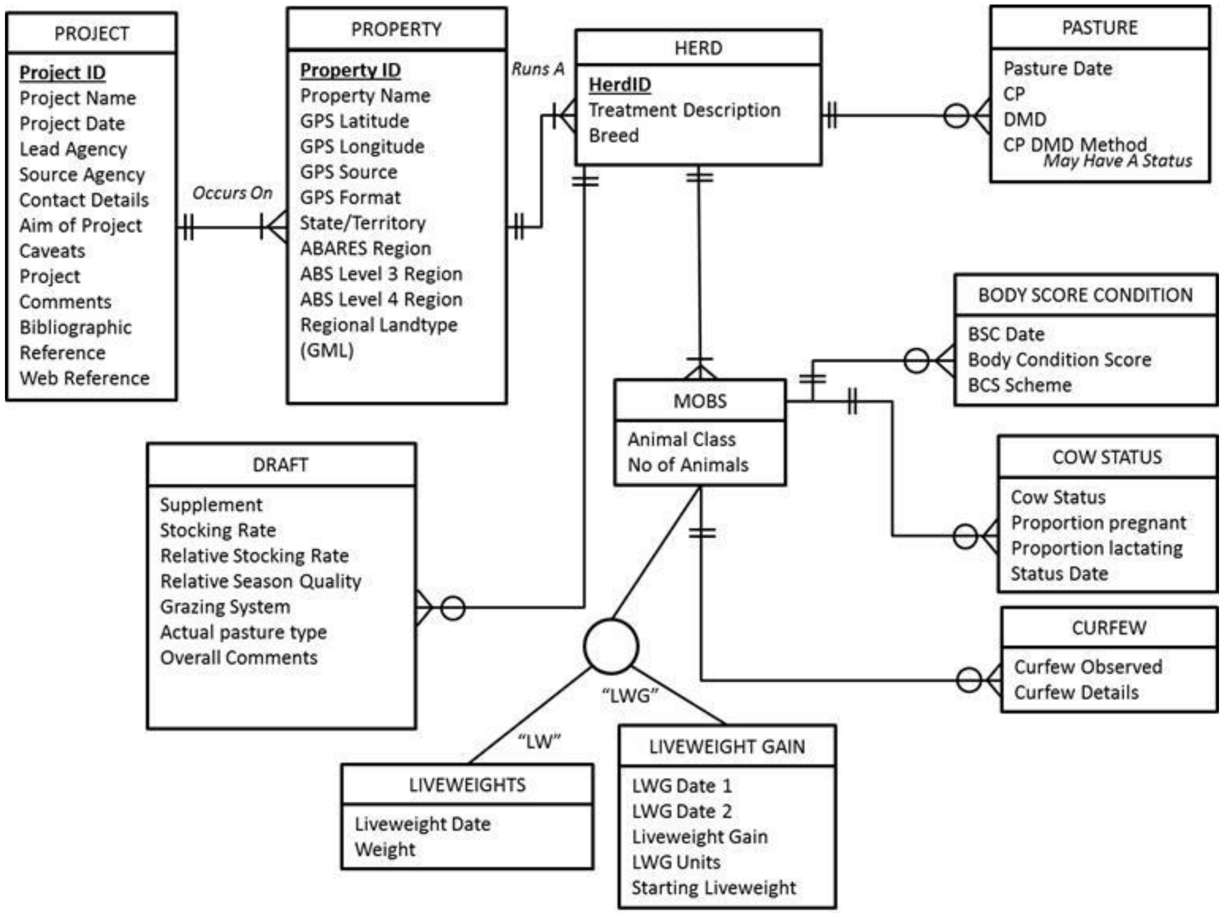


Figure 3: Enhanced entity relationship diagram for the relational database used to compile cattle liveweight data.

Regional justification

Two processes were used to evaluate, propose and justify sub-regions and the number of livestock classes within Queensland and the Northern Territory:

1. Herd LW growth patterns and productivity data (modelled and experimental data)
2. Geographic information system (GIS) mapping comparing bio-physical layers to statistical boundaries.

The target was for a maximum of 5-6 sub-regions in Queensland and 4-5 sub-regions in the Northern Territory.

The herd LW growth patterns for the 12 CSIRO sub-regions in Queensland and 4 sub-regions in the Northern Territory were visually compared to the NIR reference data and Beef CRC Breedcow Dynama template sub-region data. The amount of data available and the standard deviations of the LW data were taken into account when making comparisons between the data sources. Comparisons were also made between sub-regions to devise a sensible grouping of sub-regions to meet the target sub-region number.

Regional groupings of sub-regions were then recommended based on a narrative incorporating livestock data, production systems and region biophysical information. The GIS biophysical information layers used were:

- Beef cattle density and land use
- Average annual rainfall
- Soil organic carbon (indicator of soil fertility and rainfall)
- Soil phosphorus (indicator of soil fertility)

- Pasture productivity
- Pasture community type
- Other regional mapping based on industry or biophysical information (e.g. Cashcow regions and IBRA bioregion).

LW, LWG, DMD and CP reference tables

Seasonal LW and pasture quality data (mean, standard deviation and count) were re-extracted from the database based on the new proposed sub-regional boundaries. Seasonal LWG was subsequently calculated by subtracting the estimated liveweight at the start of the season (derived by averaging the two seasonal LW values) from the estimate of liveweight at the end of the season and dividing by 91 days (season length).

Figure 4 depicts the average regional growth trajectory (black line) and average seasonal liveweight (red squares). The liveweight at the start and end of each season was calculated from the growth trajectory (blue diamonds). The average daily seasonal LWG was calculated as the difference between the liveweight at the end and start of the season (blue line). The average seasonal LWG may include a negative daily LWG for part of the season followed by strong positive LWG for part of the season, which is averaged over the whole season to derive an average daily LWG for the season (see within green circle). The difference in time step (centre of season versus start or end of season) mean that the following seasons average liveweight cannot be directly calculated from the previous seasons average liveweight and LWG values.

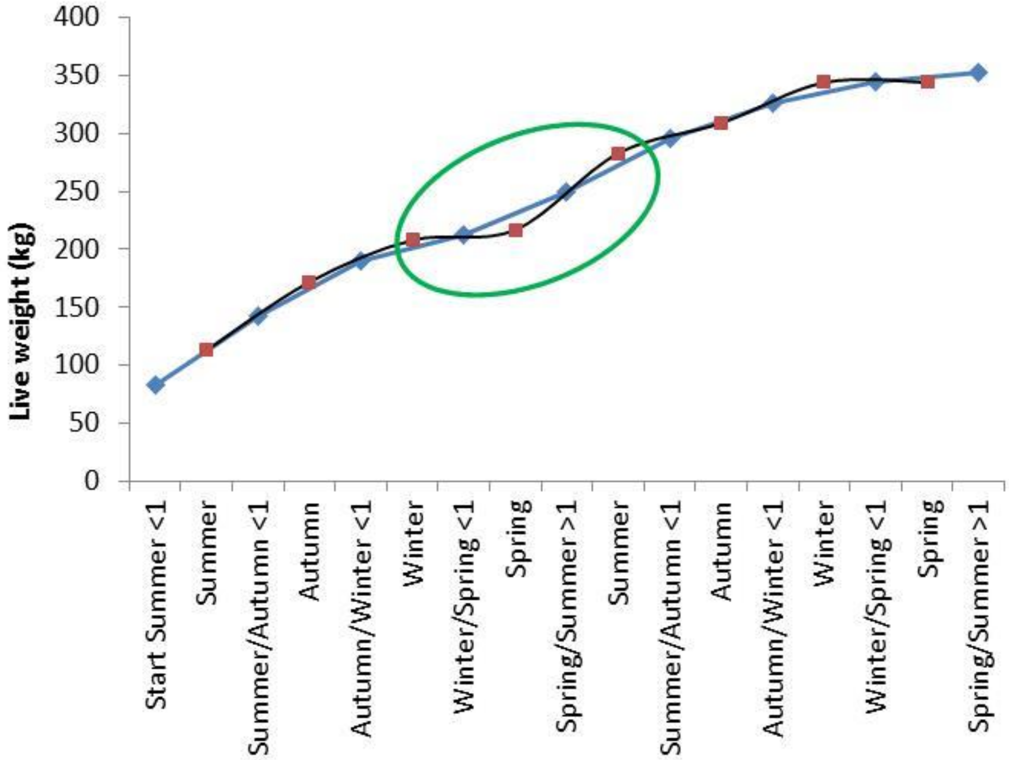


Figure 4: Example liveweight growth trajectory (black line) including average seasonal liveweight (red squares), start and end season liveweight (blue diamonds) and seasonal growth (blue line).

Reference data tables based on the NIR template were developed for LW, LWG, CP and DMD for the proposed regions in Queensland and the Northern Territory.

Allocating proportion of herd number to each livestock class

ABS provides regional total beef cattle number and some data on numbers in specific cattle classes. However ABS beef cattle classes for which data are collected have varied over time, complicating the use of the class data. The number of cattle in feedlots is also collected. Regional Breedcow Dynama herd models (DAF 2015) document the typical herd structure (not including cattle in feedlots) for each region in northern Australia and were used to estimate the proportion of the annual regional herd (in animal numbers, not adult equivalents) in each beef cattle class. The steps were:

- For each region the relative number of cattle in each class was estimated, taking into account sale date (e.g. 100 cows 1-2yrs sold 6 months into year equals 50 cows 1-2yrs for the full year).
- Based on regional cattle numbers (Appendix 3), the weighted number of cattle in each class were calculated for each combined region.
- The proportion of total cattle number for each class in each region was then calculated.
- The number of weaners produced was used to estimate the proportion of the Cows >2 (Cows 2-3 plus >3) that were lactating for the full period. Bulls <1 year were calculated from the Bulls >1 number divided by 6 years of service. The Bulls <1 year would replace the bulls required for mating as they were removed from the herd (through death or culling).

Other assumptions included:

- The regional Breedcow Dynama models represent the herd structure at the regional scale, despite variation at the individual property scale.
- The regional Breedcow and Dynama models assume cattle are sold to live export (e.g. Northern NT), feedlots (e.g. Queensland High productivity) or slaughter (e.g. Queensland Moderate/High productivity). After sale/transfer from the grazing property to a feedlot, the cattle are assumed to have left the grazing herd in the region and will be accounted for in the feedlot numbers.
- Bulls <1 plus Steers <1 equal Heifer <1 numbers.
- Number of weaners equals the number of cows lactating for the full lactation period.

Results

Data collation

Over 7500 beef cattle liveweight records were accessed and collated for 4348 mobs, 2196 herds and 134 data sources (Appendix 2) and imported into the database. Many of the pre-1999 datasets were extracted from Hasker (2000). Liveweight data were accessed from across Queensland and the Northern Territory with the majority of data from less-remote, higher beef producing regions (Figure 5). Many of the more comprehensive datasets with regular intra-seasonal liveweight data for the same mob were from regional research stations.

Fewer pasture quality datasets were available, and this was particularly acute in more remote regions.

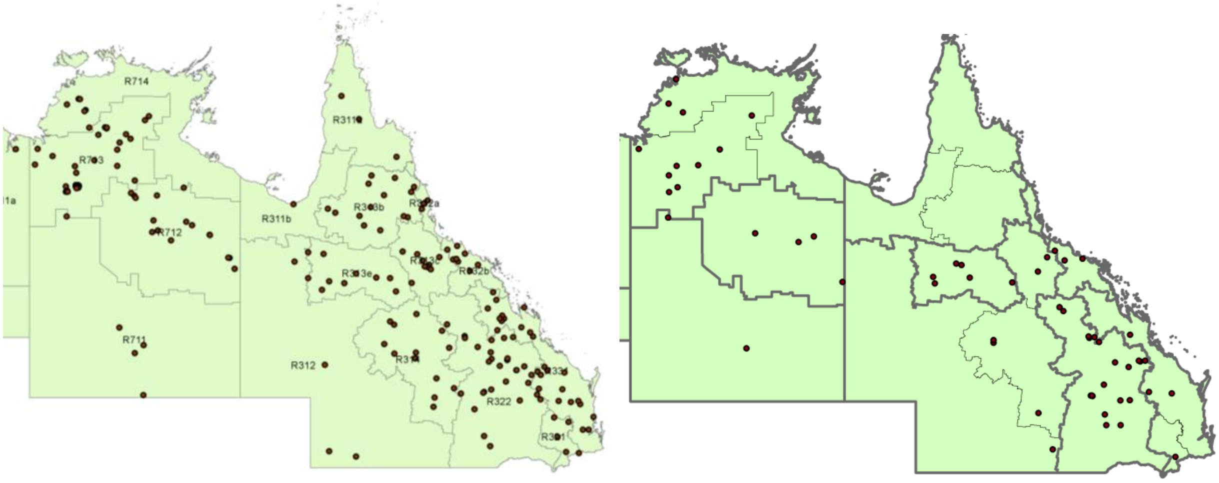


Figure 5: Locations of beef cattle liveweight data (left) and pasture quality data (right) accessed for the project.

Significant quantities of relevant data would be held by corporate pastoral companies which we did not have access to. Access to corporate pastoral company data in more remote regions would help to provide greater accuracy for LW, LWG, CP and DMD values.

Regional biophysical information

Selection of regional boundaries was based on ABS SA2 statistical boundaries which are used to collect livestock numbers across Australia. CSIRO amalgamated ABS SA2 regions into 12 sub-regions in Queensland and 4 sub-regions in the Northern Territory (Eady and Navarro, unpublished). For the purposes of the National Inventory Reporting, a maximum of 5-6 regions in Queensland and 4-5 regions in the Northern Territory were desirable.

Biophysical and industry maps and statistics based on the CSIRO SA2 regional groups were collated and utilised to justify further combining the SA2 regional groups into sub-regions of Queensland and the Northern Territory (Figures 6 to 16; Appendix 3). The biophysical data indicated a large range in regional area, beef cattle number, rainfall, soil fertility and pasture types between regions.

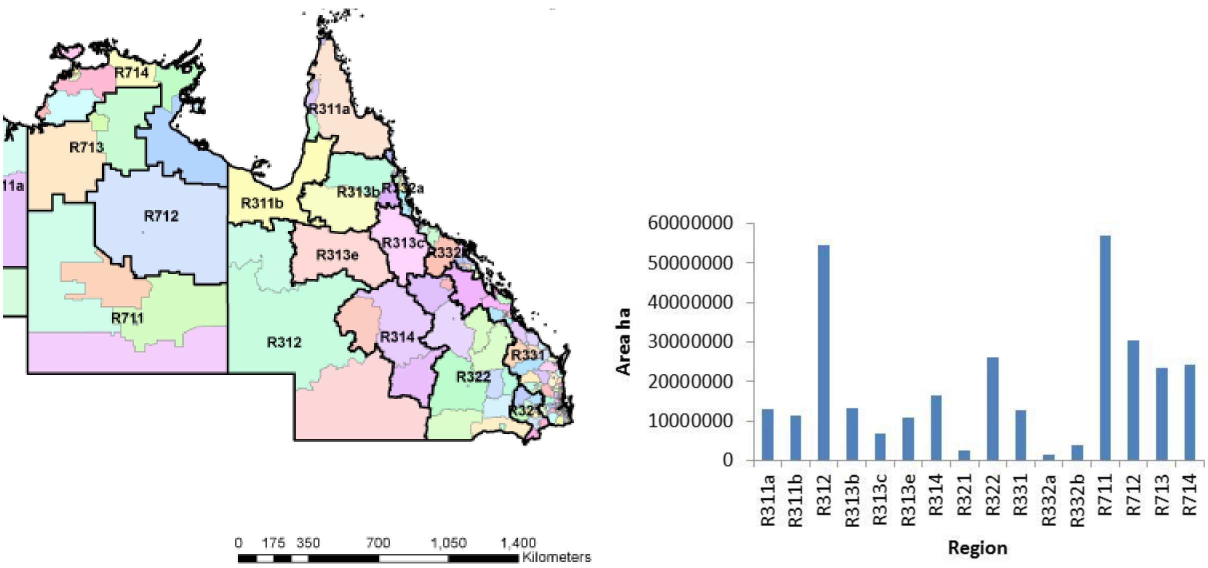


Figure 6: Regional boundaries based on Breedcow Dynama representative herd models and Australian Bureau of Statistics SA2 boundaries (Eady and Navarro, unpublished) and land area for each region.

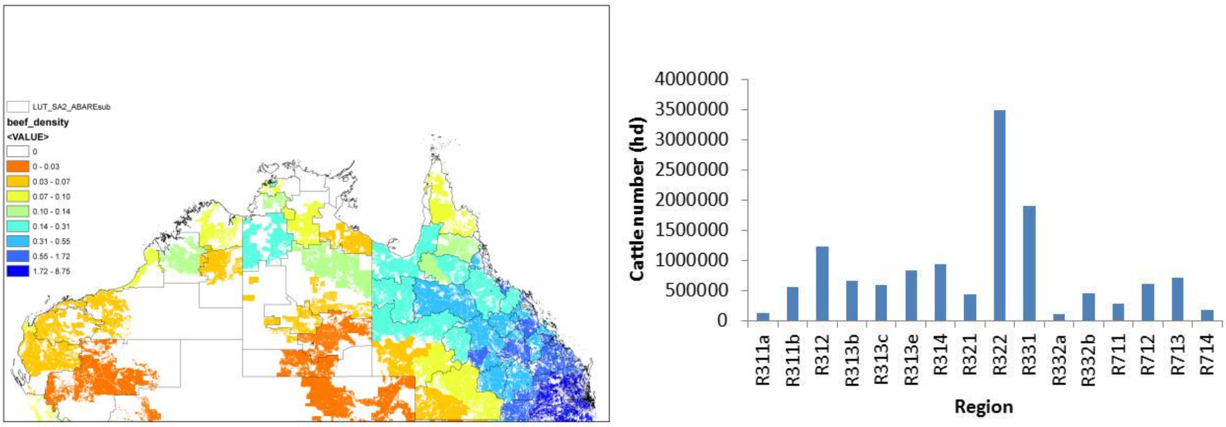


Figure 7: Beef cattle land use and beef cattle density map and regional cattle numbers. White areas on the map indicate no beef cattle are commercially grazed (Data source: Carter *et al*. 1996 and 2003)

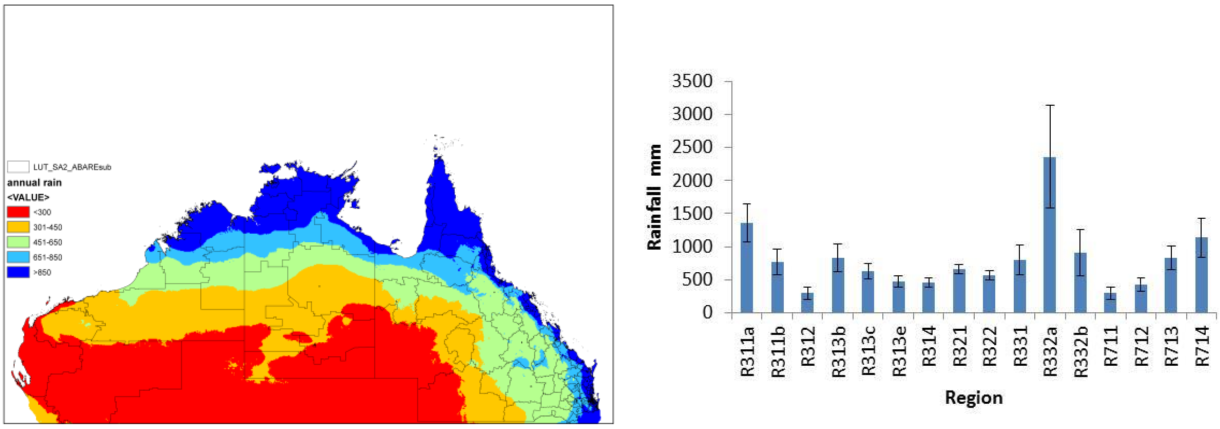


Figure 8: Average annual rainfall map and regional average rainfall (mm). (Data source: BoM 2015)

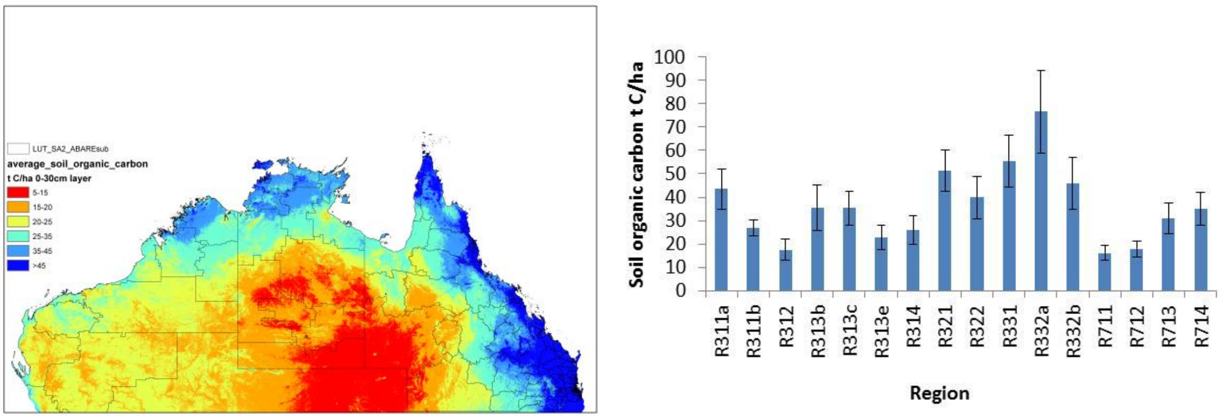


Figure 9: Soil organic carbon (indicator of soil fertility and rainfall) map and regional average soil organic matter (t C/ha to 30cm). (Data source: Viscarra Rossel *et al*. 2014a)

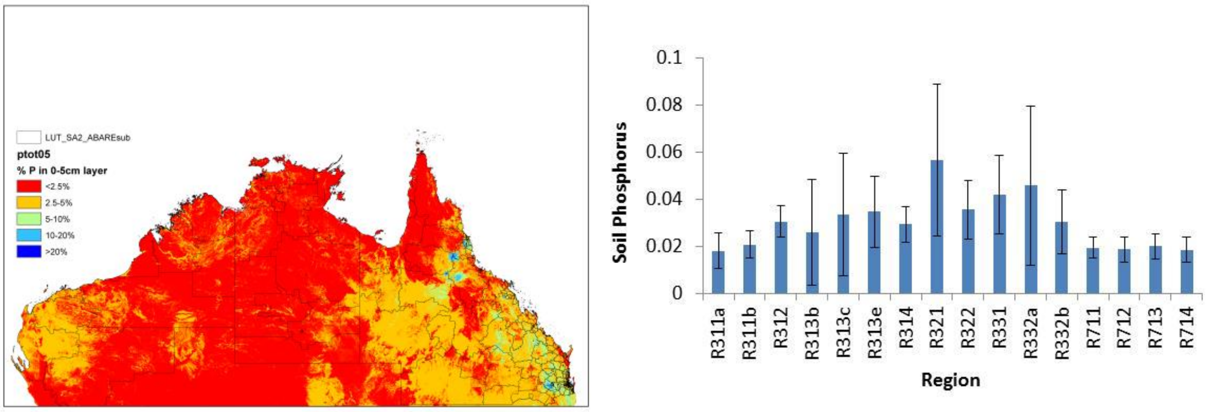


Figure 10: Total soil phosphorus (indicator of soil fertility) map and regional average soil phosphorus (% in 0-5cm layer, map legend divided by 100). (Data source: Viscarra Rossel *et al*. 2014b)

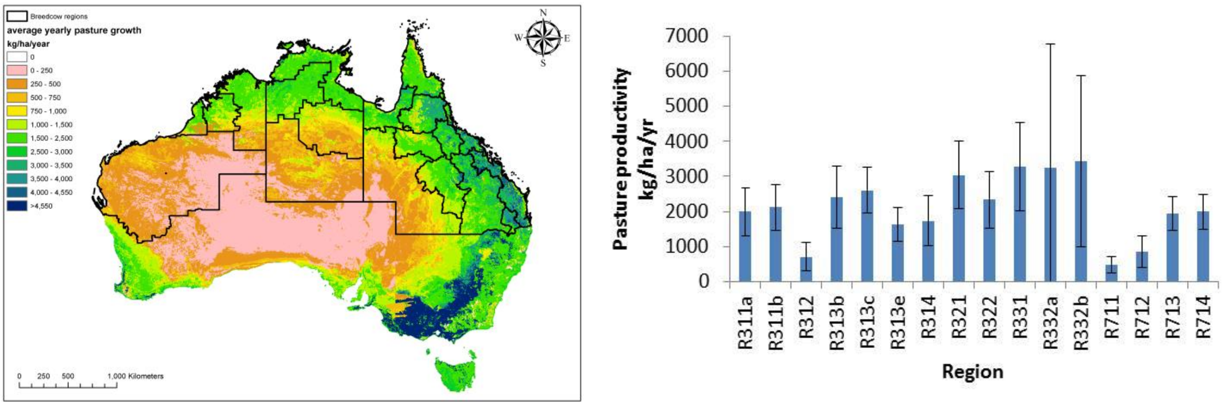


Figure 11: Pastoral productivity (kg/ha/yr) in northern Australia based on AussieGrass modelling. Data provided by John Carter and Grant Stone.

Other industry regional mapping (e.g. Pasture type, Northern Beef report, Cashcow regions and IBRA bioregions) (Figures 12 to 16) provided some guidance on the grouping of sub-regions.

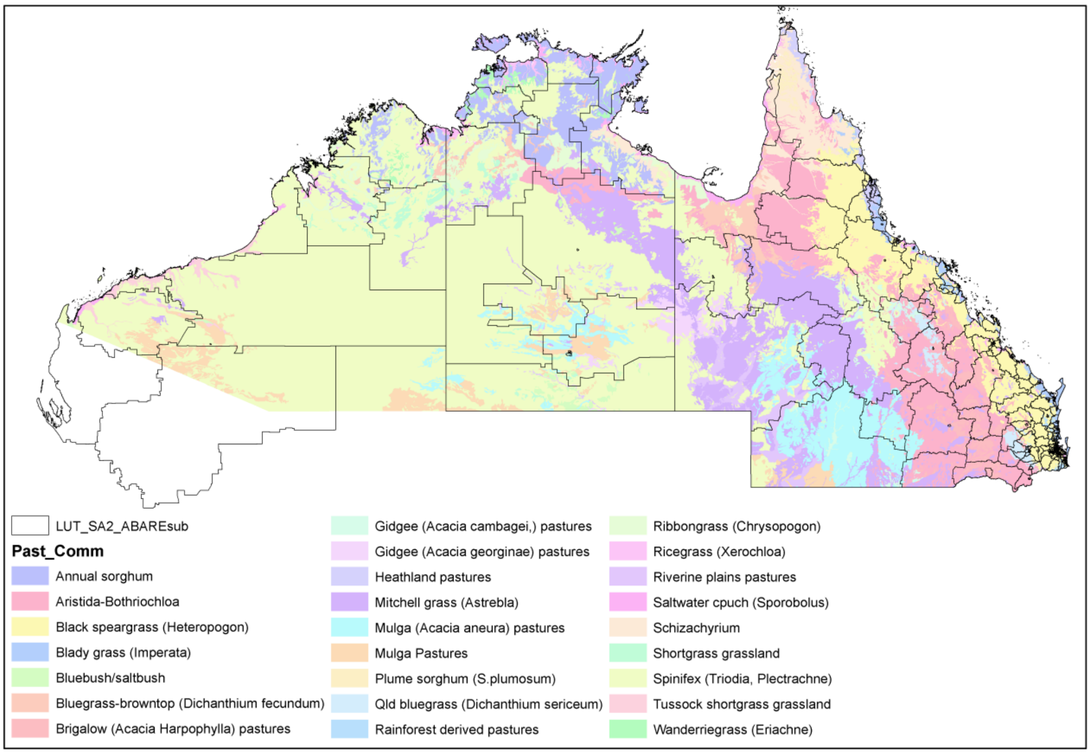


Figure 12: Pasture land types in northern Australia (based on Tothill and Gillies (1992); data layer supplied by Grant Stone).

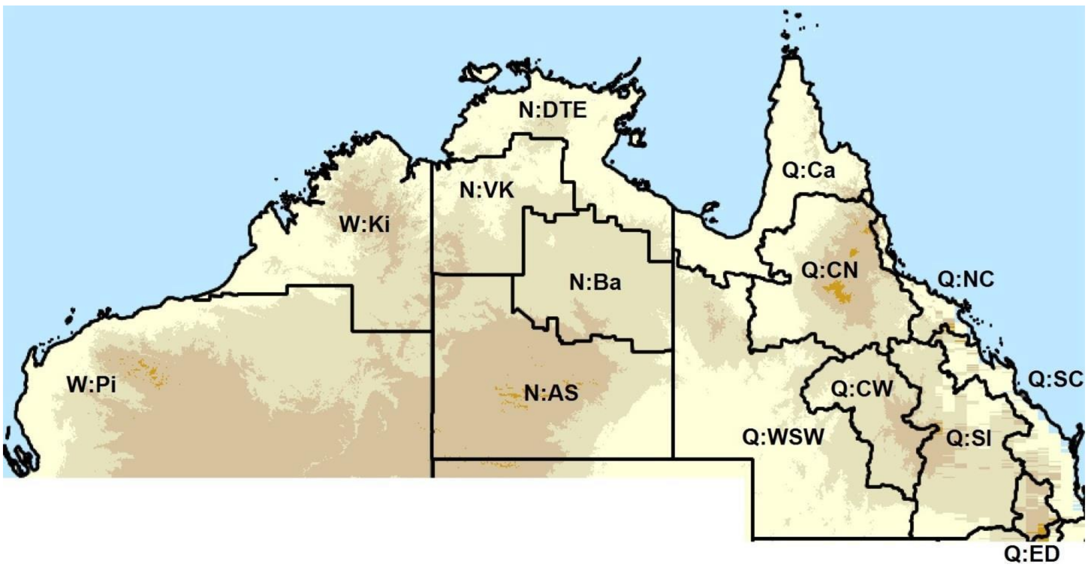


Figure 13: Regions analysed by the Northern Beef report (McLean *et al*. 2014) based on ABARE regions.

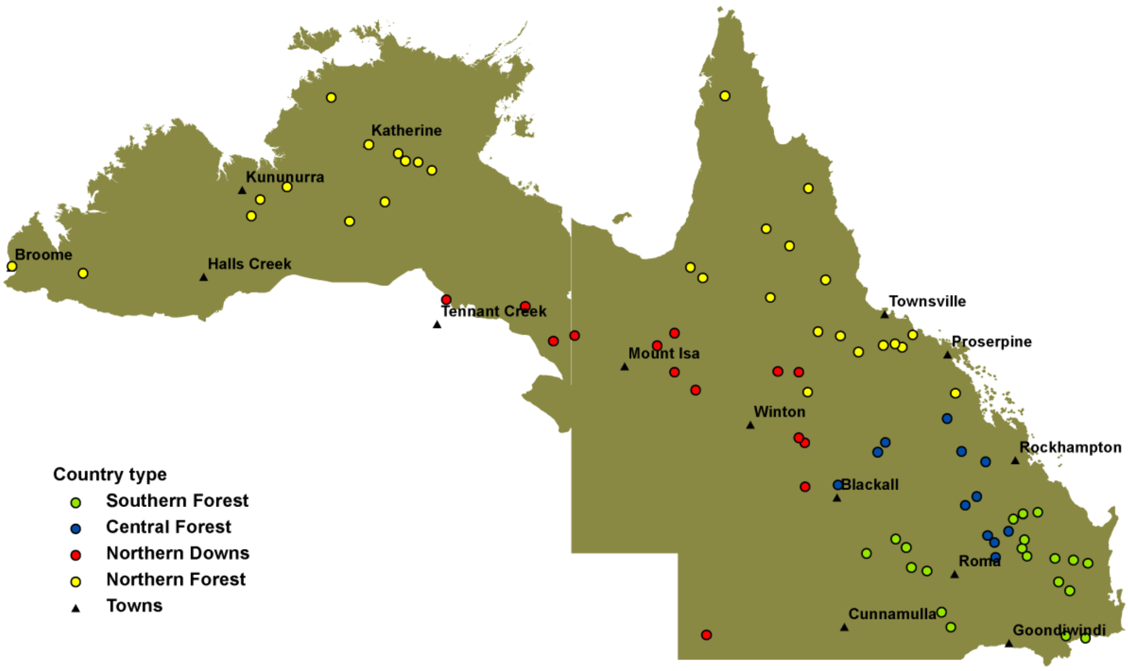


Figure 14: The Cashcow project classified the northern Australian beef industry into 4 country type categories (McGowan *et al*. 2014).

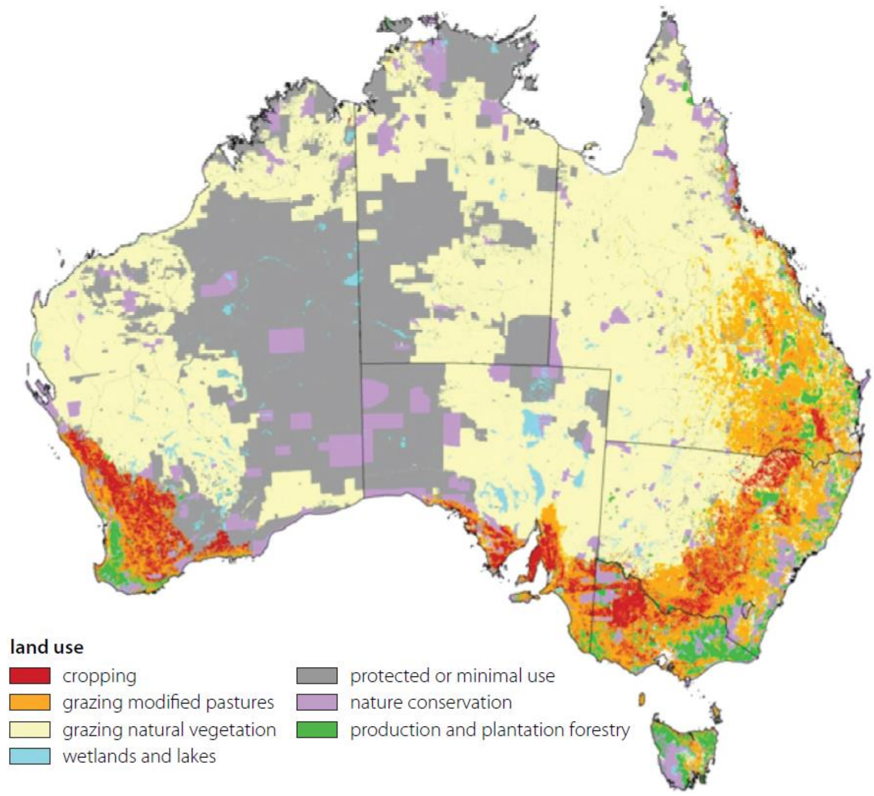


Figure 15: Grazing land distribution in Australia. Image from the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES) (Sparkes *et al*. 2011). Land use classes are based on the Australian Collaborative Land Use and Management Classification.

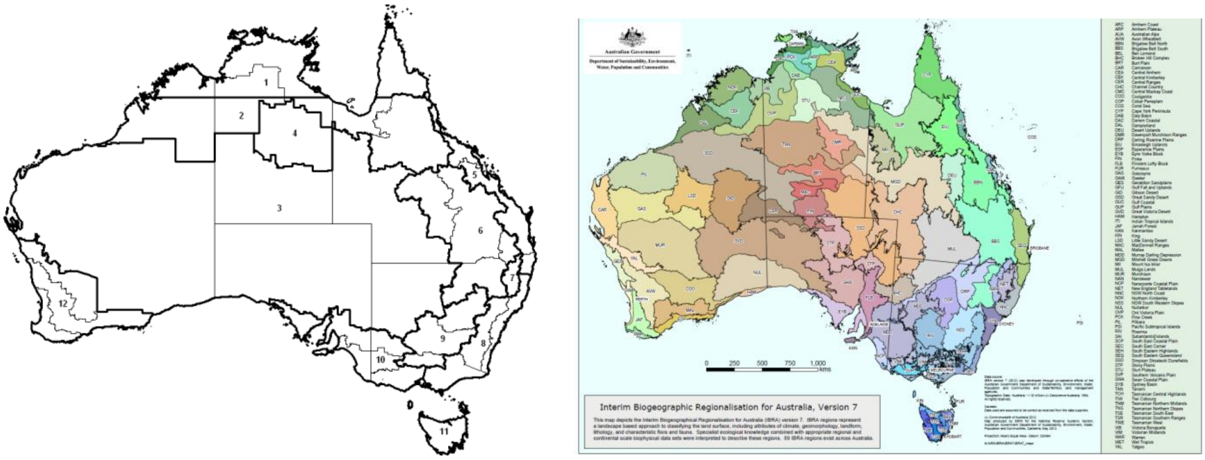
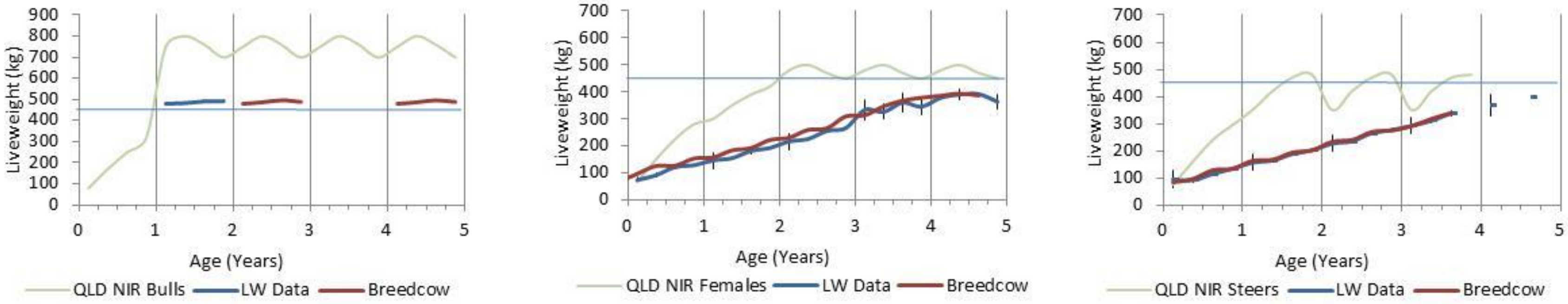


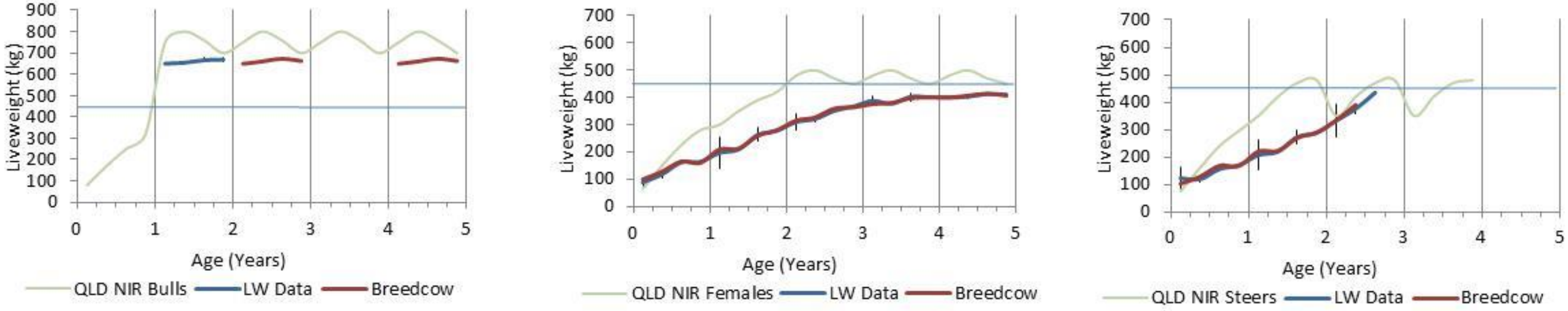
Figure 16: Beef regions defined by AusVet (2006) using FAO classification of agricultural land (left) and IBRA bioregions (right).

Regional LW data

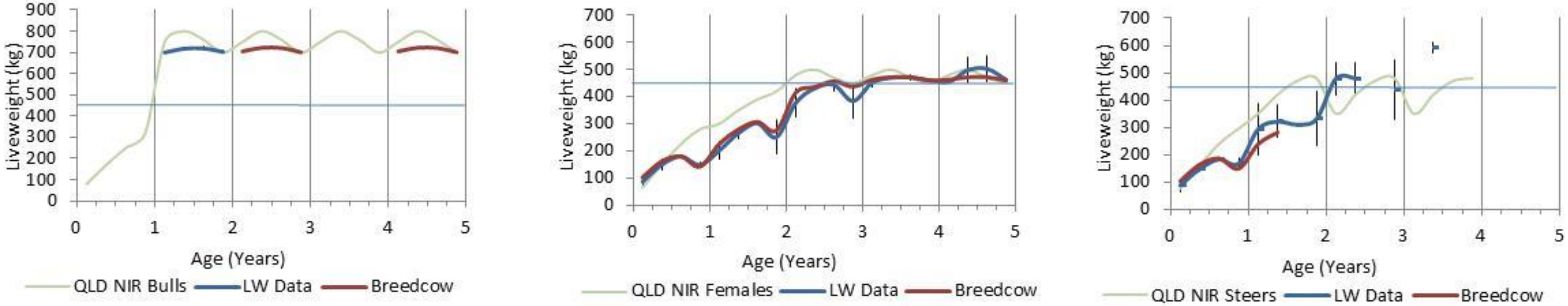
Experimental LW data (mean, standard deviation and count) were extracted from the database for each season, age of livestock and each of the regions defined by CSIRO. The data were graphed for bulls, females and steers based on age and compared to the NIR reference data and the Beef CRC Breedcow Dynama representative herd data for each region (Figure 17). These graphs were visually evaluated for similarities and differences between datasets, appropriateness of livestock age classes and similarities to other regions for livestock productivity. Notes on this evaluation are presented in Table 3, 4 and 5.



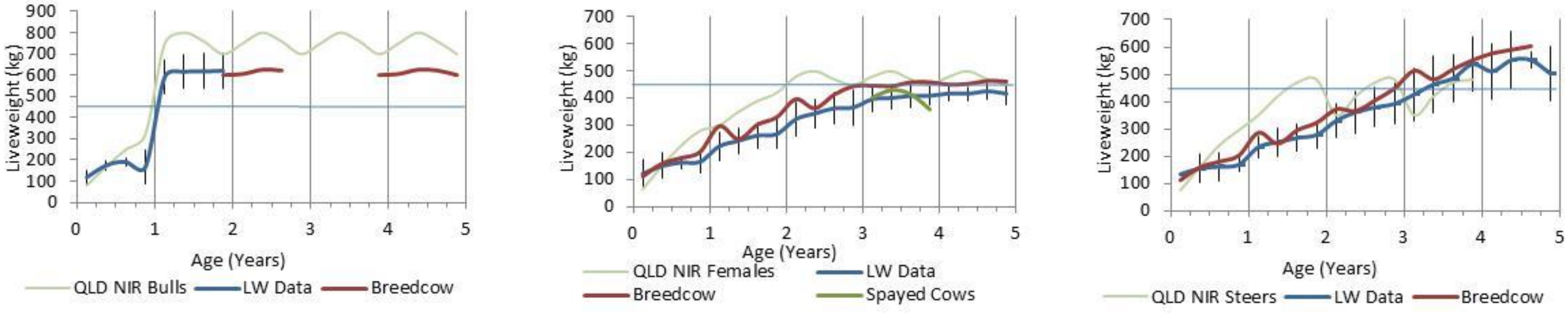
R311A



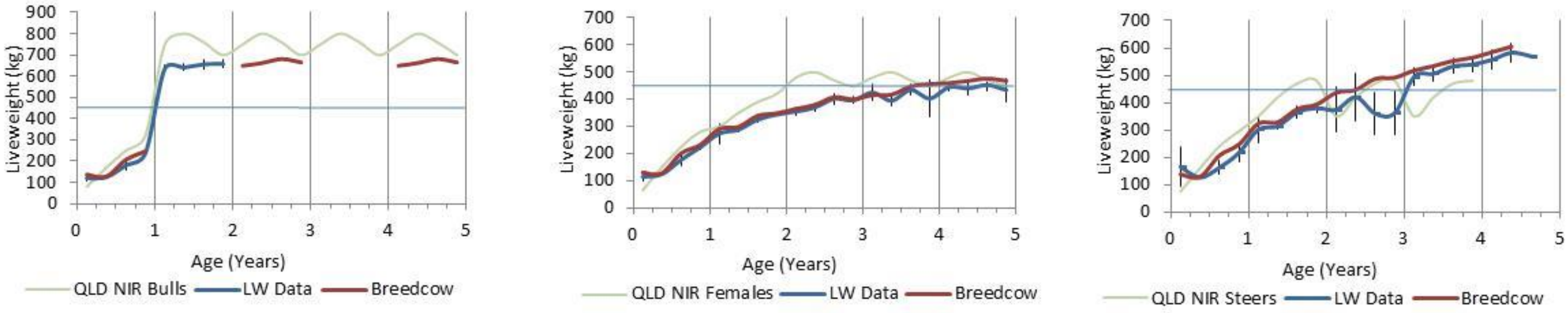
R311B



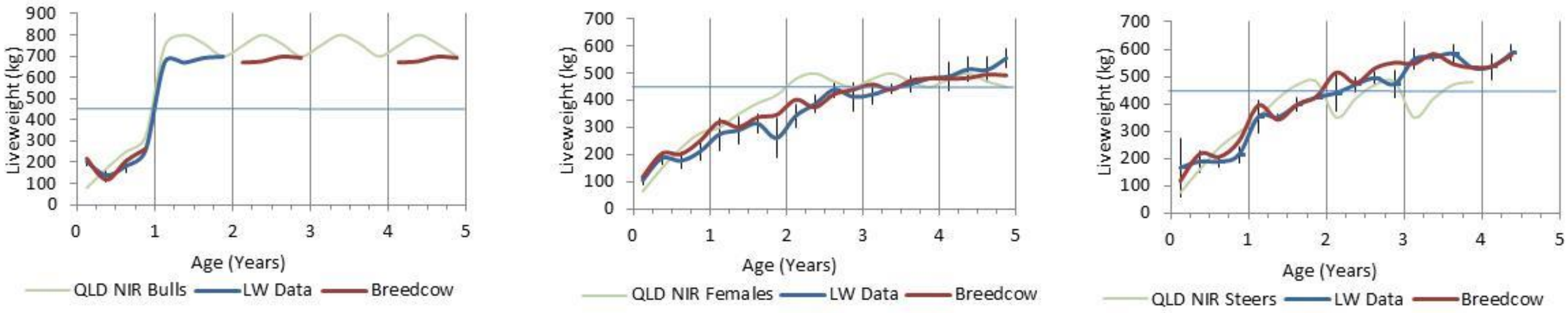
R312



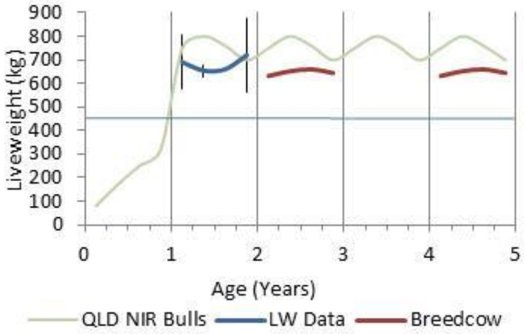
R313B

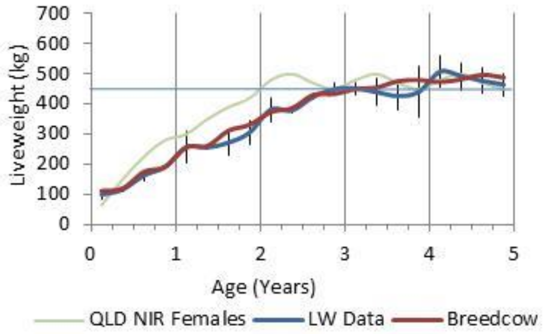


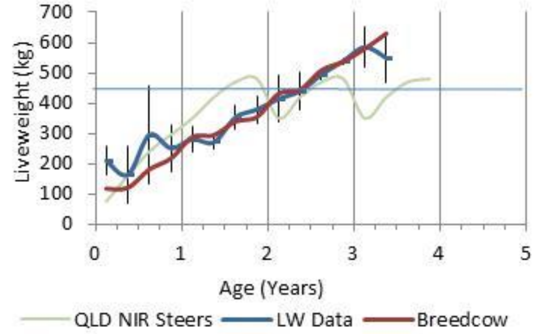
R313C



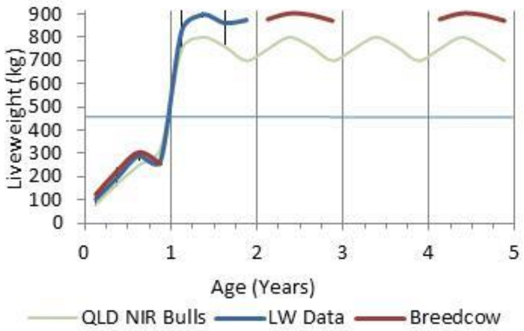
R313E

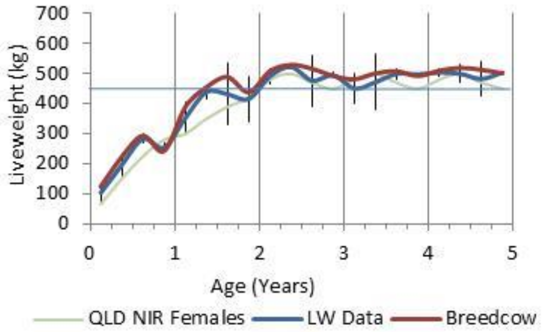


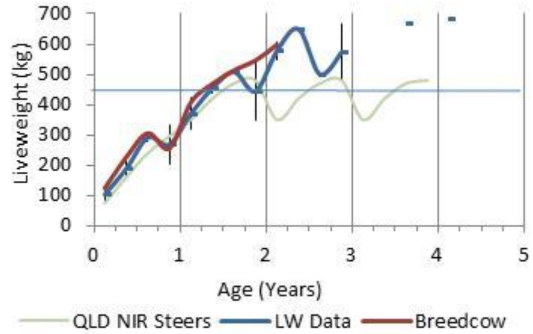




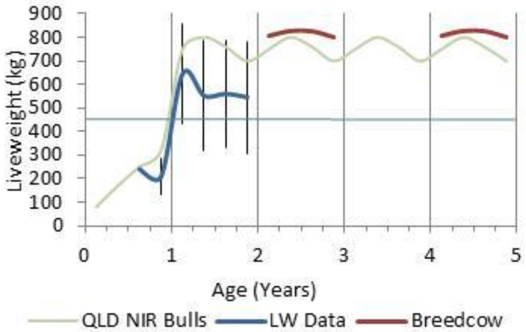
R314

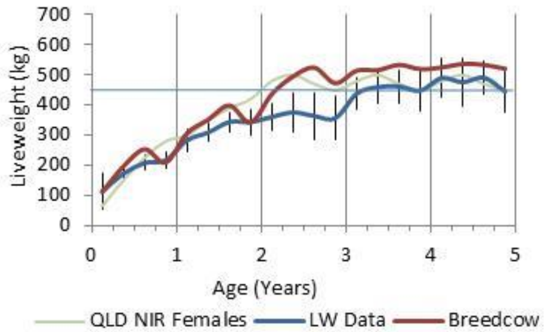


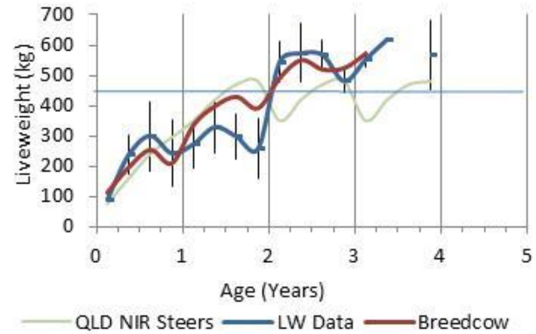




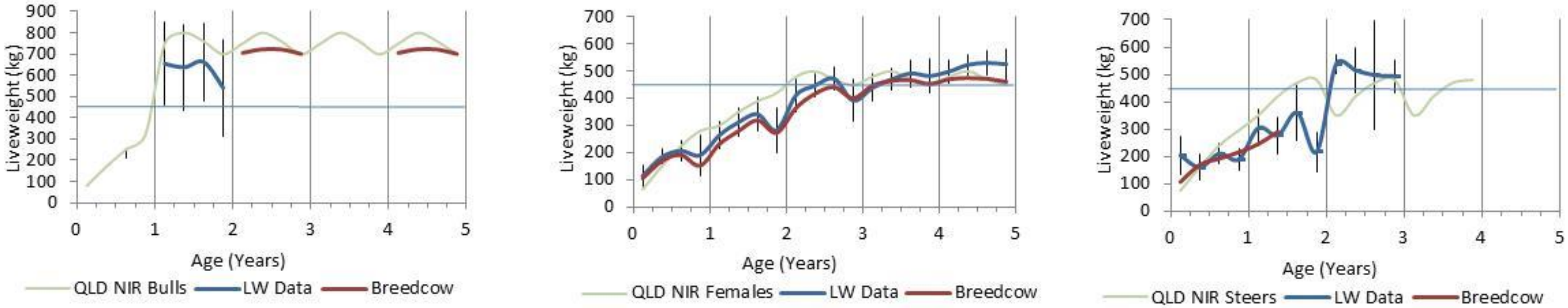
R321



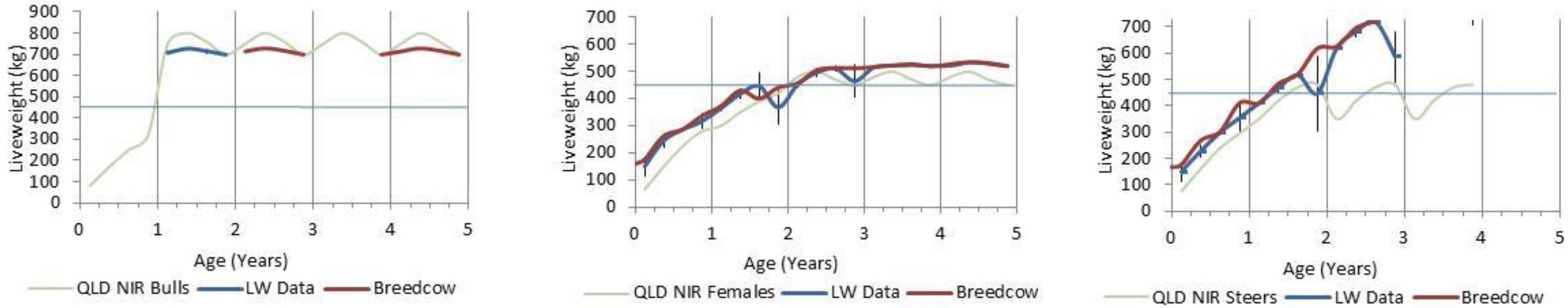




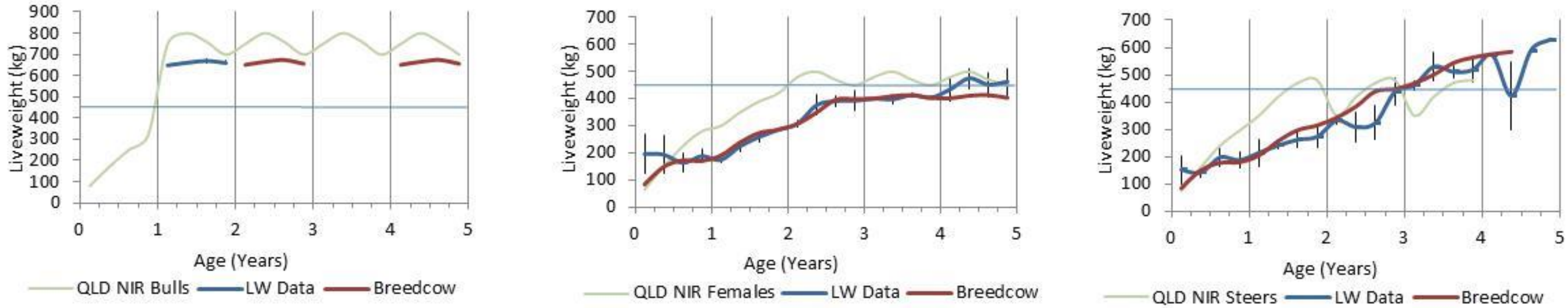
R322



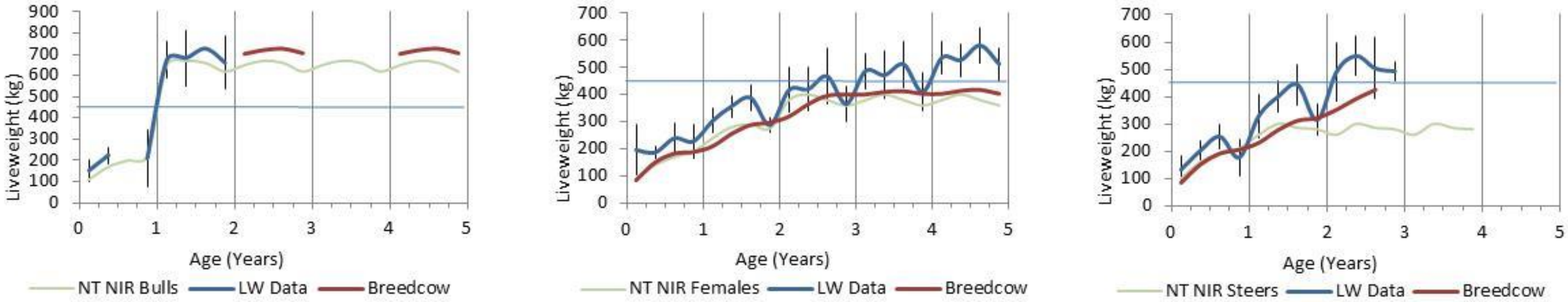
R331



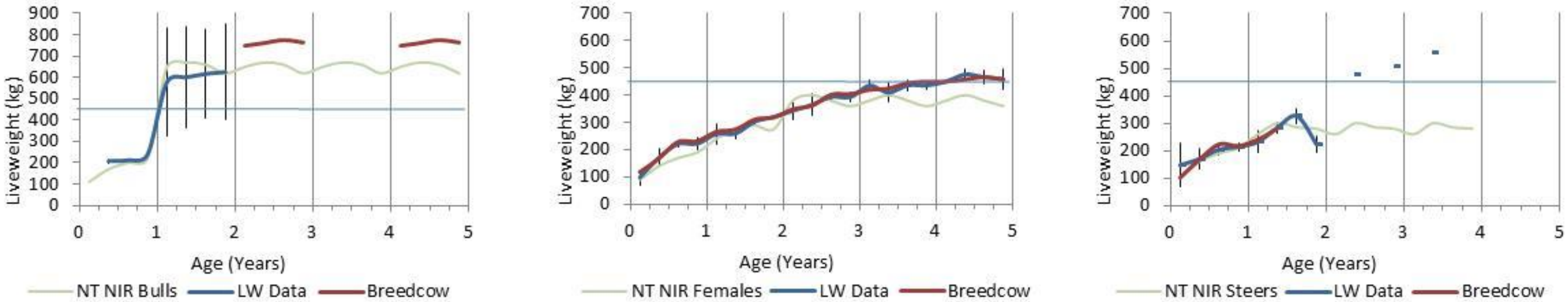
R332A



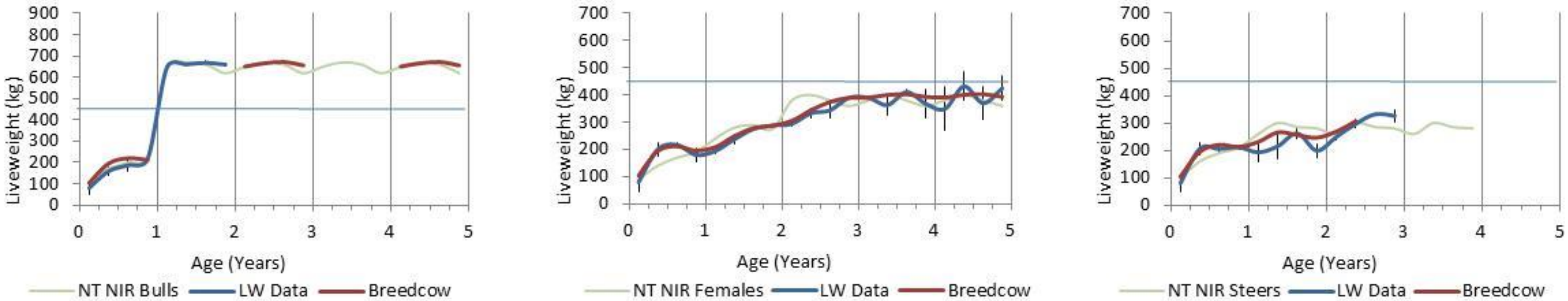
R332B



R711



R712



R713

R714

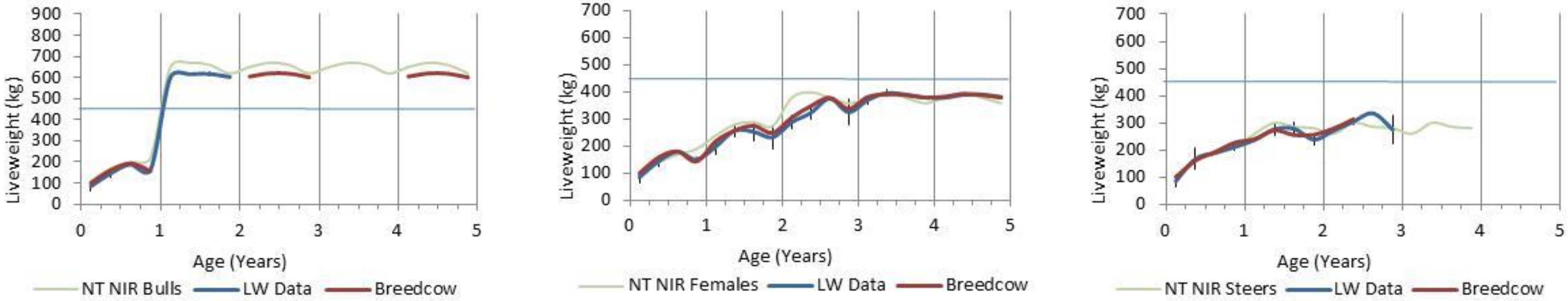


Figure 17: Average seasonal liveweight data for bulls (left), females (centre) and steers (right) compared to the NIR reference data and the regional Breedcow Dynama representative herd models. Error bars are the standard deviation (SD). Bulls data was classified as less than or greater than 1 year which generates a large increase spanning the 1 year boundary. The blue 450kg adult equivalent (AE) line is included on the graph as a comparative reference.

Table 3: Visual assessment notes from examining bull seasonal liveweight data (Figure 17) for each region.

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
R311A	No data. Not many 'quality' bulls grown in this region. Would be a lot of mickey non-branded bulls. Could use Breedcow Dynama steer growth.	Much lower than NIR. Breedcow Dynama good.	Probably need 1-2 and 2+, but not many bulls grown in this region. Could use Breedcow Dynama steer growth.	Most similar to 311B	Low herd size, very low productivity. Low number of data points.
R311B	No data. Not many 'quality' bulls grown in this region. Could use Breedcow Dynama steer growth.	Slightly lower than NIR. Breedcow Dynama good.	Probably need 1-2 and 2+, but not many bulls grown in this region. Could use Breedcow Dynama steer growth.	Most similar to 332B, 313B, 313C	Low number of data points.
R312	No data. Could use Breedcow Dynama steer growth.	Similar to NIR. Breedcow Dynama good.	Probably need 1-2 and 2+. Could use Breedcow Dynama steer growth.	Most similar to 311B, 313B, 313C, 313E, 314, 331, 332A, 332B	Low number of data points.
R313B	Lower than NIR. No Breedcow Dynama data. Could use steer data.	Lower than NIR. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	311B, 312, 313C, 313E, 314, 331, 332A, 332B	Good number of data points.
R313C	Slightly lower than NIR. Breedcow Dynama good.	Lower than NIR. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313E, 314, 331, 332A, 332B	Good number of data points.
R313E	Slightly lower than NIR. Breedcow Dynama good.	Lower than NIR. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313C, 314, 331, 332A, 332B	Low number of data points.
R314	No data. Could use Breedcow Dynama steer growth.	NIR good but offset. Breedcow Dynama good.	Probably need 1-2 and 2+. Could use Breedcow Dynama steer growth.	311B, 312, 313B, 313C, 313E, 331, 332A, 332B	Low number of data points.
R321	NIR good. Breedcow Dynama good but	Higher than NIR. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to	Higher than others. Most similar to 332, 331	Low number of data points. Low herd size (4% of herd)

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
	supplement with steer data.		combining 1+ bulls.		consider combining with 322.
R322	Lower than NIR. No Breedcow Dynama data. Could use steer data.	Lower than NIR. Lower than Breedcow Dynama. High SD, probably due to mixing 1+ ages.	Need 1-2 and 2+. Big jump and high SD after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313C, 313E, 314, 331, 332A, 332B	Good number of data points.
R331	Little data. Could use Breedcow Dynama steer growth.	Lower than NIR. Breedcow Dynama good. High SD, probably due to mixing 1+ ages.	Need 1-2 and 2+. Big jump and high SD after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313C, 313E, 314, 322, 332A, 332B	Good number of data points.
R332A	No data. Could use Breedcow Dynama steer growth.	NIR good. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313C, 313E, 314, 322, 331, 332B	Low number of data points. Low herd size (1% of herd) consider combining with another region maybe 312.
R332B	No data. Could use Breedcow Dynama steer growth.	Lower than NIR. Breedcow Dynama good.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	311B, 312, 313B, 313C, 313E, 314, 322, 331, 332A	Low number of data points.
R711	Similar to NIR. No Breedcow Dynama data. Could use steer data.	No mature bull data >2 years. Breedcow Dynama appears more consistent with the growth trajectory than NIR.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	Unique production environment worthy of own region.	Reasonable number of data points.
R712	Similar to NIR but little data. No Breedcow Dynama data. Could use steer data.	Limited data and high SD. Ranges consistent with NIR and Breedcow Dynama but averages more similar to NIR. Breedcow Dynama much higher than NIR.	Need 1-2 and 2+. Big jump after 1 year and SD high due to combining 1+ bulls.	Unique production environment worthy of own region.	Low number of data points. Good match between data, Breedcow Dynama and NIR.
R713	Similar to Breedcow Dynama and NIR.	No mature bull data >2 years. Breedcow Dynama and NIR match well and are consistent with data growth trajectory.	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	Similar to R714.	Low number of data points.
R714	Similar to Breedcow Dynama and NIR.	No mature bull data >2 years. Breedcow Dynama appears more consistent with the	Need 1-2 and 2+. Big jump after 1 year due to combining 1+ bulls.	Similar to R713.	Low number of data points and they are confined to the western part of the region. Current SA2 group incorporates

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
		growth trajectory than NIR. Slightly lower than NIR.			vast differences in productivity and cattle densities. It would be reasonable to coalesce with R713 to accommodate this variability.

Table 4: Visual assessment notes from examining female seasonal liveweight data (Figure 17) for each region.

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
R311A	Much lower and slower than NIR. Breedcow Dynama good.	Much lower than NIR. Breedcow Dynama good.	Heifers 2-3 still small and growing. 3-4 still growing but only slightly lower than 4+.	311B, 332B, 313B	Low herd size 1% but very low productivity. Low number of data points.
R311B	Lower and slower than NIR. Breedcow Dynama good.	Lower than NIR. Breedcow Dynama good.	Heifers 2-3 still small and growing. 3-4 still growing but only slightly lower than 4+.	332B, 313B, 313C	Low number of data points.
R312	Lower and slower than NIR. Breedcow Dynama good.	NIR good. Breedcow Dynama good.	Heifers 2-3 still growing. 3-4 and 4+ are similar.	313B, 313C, 313E, 314, 331, 332B	Low number of data points.
R313B	Lower and slower than NIR. Slightly lower than Breedcow Dynama.	Slightly lower than NIR. Slightly lower than Breedcow Dynama.	Heifers 2-3 still growing. 3-4 and 4+ are similar. Spayed cows were a good fit with 3-4 data so a separate spayed class not required.	311B, 312, 313C, 313E, 314, 331?, 332B	Good number of data points.
R313C	Lower and slower than NIR. Breedcow Dynama good.	Slightly lower than NIR. Slightly lower than Breedcow Dynama.	Heifers 2-3 still growing. 3-4 and 4+ are similar.	311B, 312, 313B, 313E, 314, 322 (LW data), 331, 332B	
R313E	Lower and slower than NIR. Breedcow Dynama good.	NIR good. Breedcow Dynama good.	Heifers 2-3 still growing. 3-4 still growing.	312, 313B, 313C, 314, 322 (LW data), 331	Good number of data points.
R314	Lower and slower than NIR. Breedcow Dynama good.	NIR good. Breedcow Dynama good.	Heifers 2-3 still growing. 3-4 and 4+ are similar.	312, 313B, 313C, 313E, 322 (LW data), 331	
R321	Higher than NIR. Breedcow Dynama good.	NIR good. Breedcow Dynama good.	Heifers reach maximum weight about 2, therefore similar after 2+.	332A 313E, 322 and 331 have similar mature weight just slightly slower.	Low number of data points.
R322	Slightly lower than NIR. Slightly lower than Breedcow Dynama.	NIR good. Slightly lower than Breedcow Dynama.	Heifers 2-3 still growing. 3-4 and 4+ are similar.	312, 313B, 313C,313E, 314, 331	Good number of data points.

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
R331	Lower than NIR. Breedcow Dynama good.	NIR good. Breedcow Dynama good.	Heifers 2-3 still growing. 3-4 still growing but only slightly lower than 4+.	312, 313B, 313C,313E, 314, 322	Good number of data points
R332A	Higher than NIR. Breedcow Dynama good.	Higher than NIR. Breedcow Dynama good.	Heifers 2-3 still growing. 3-4 and 4+ are similar.	321 313E, 322 and 331have similar mature weight just slightly slower.	Low number of data points. Low herd size (1% of herd).
R332B	Lower and slower than NIR. Breedcow Dynama good.	Lower than NIR in 3-4 cows, then NIR good. Breedcow Dynama good in 3-4 cows, then Breedcow Dynama low.	Heifers 2-3 still growing. 3-4 still growing but only slightly lower than 4+.	311B, 313B, 313C, 314?	Good number of data points.
R711	Similar growth rate but higher average LW than both NIR and Breedcow Dynama (see comments).	Higher than both NIR and Breedcow Dynama (see comments). Does not plateau off as early as NIR and Breedcow Dynama.	Heifers 2-3 still growing. 3-4 still growing and lower than 4+.	Unique production environment worthy of own region.	Good number of data points but from a limited number of locations. Most data points are from well-managed herds in the region and averages may be higher than typical for industry.
R712	Breedcow Dynama excellent. Slightly higher than NIR.	Breedcow Dynama excellent. Does not plateau off as early as NIR and finishes higher than NIR.	Heifers 2-3 still growing. 3-4 still growing but only slightly lower than 4+.	Unique production environment worthy of own region.	Reasonable number of data points.
R713	Breedcow Dynama excellent. NIR good.	Breedcow Dynama and NIR good (with exception of jump in NIR at 2-3). Does not plateau off as early as NIR but finishes similar to NIR.	Heifers 2-3 still growing. Mature weight reached at 3-4 and similar to 4+.	Similar to R714.	Good number of data points.
R714	Breedcow Dynama excellent. Similar to NIR.	Breedcow Dynama excellent. NIR good (with exception of jump in NIR at 2-3).	Heifers 2-3 still growing. Mature weight reached at 3-4 and similar to 4+.	Similar to R713.	Low number of data points and they are confined to the western part of the region. Current SA2 group incorporates

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
					vast differences in productivity and cattle densities. It would be reasonable to coalesce with R713 to accommodate this variability.

Table 5: Visual assessment notes from examining steer seasonal liveweight data (Figure 17) for each region.

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
R311A	Much lower and slower than NIR. Breedcow Dynama good.	Much lower than NIR. Breedcow Dynama good. Still growing up to 4+ years.	Probably need 1-2 and 2+, still small and growing as yearlings. Still growing up to 4+ years.	311B, 313B, 332B	Low herd size but very low productivity.
R311B	Much lower and slower than NIR. Breedcow Dynama good.	Much lower than NIR. Breedcow Dynama good. Still growing up to 2+ years.	Probably need 1-2 and 2+, still small and growing as yearlings. Still growing up to 2+ years. Few steers in this region grown through to bullocks.	332B, 313B, 313C	Low number of data points. Few steers in this region grown through to bullocks.
R312	Lower than NIR. Breedcow Dynama good but steers keep growing to turnoff weights at 2.5 to 4 years.	NIR good 2-3 but probably some big older bullocks. Breedcow Dynama doesn't reach mature weight but probably should.	Probably need 1-2 and 2+, still small and growing as yearlings. Still growing up to 2+ years. Steers are grown through to bullocks in this region depending on the season.	311B, 313B, 313C, 314, 331, 332B	Low number of data points. Steers in this region grown through to bullocks depending on season and country type e.g. access to channels.
R313B	Much lower and slower than NIR. Breedcow Dynama good.	NIR good 2-3 but probably some big older bullocks. Breedcow Dynama good.	Need 1-2 and 2+, still small and growing as yearlings. Still growing up to 4+ years.	311B, 312, 313C, 314?, 332B	Good number of data points.
R313C	Lower and slower than NIR. Breedcow Dynama good.	NIR good 2-3 but probably some big older bullocks. Breedcow Dynama good.	Need 1-2 and 2+, still small and growing as yearlings. Still growing up to 4+ years.	312, 313B, 313E?, 314, 322?, 331	Good number of data points.
R313E	NIR good to 2-3. Breedcow Dynama good.	NIR good 2-3 but probably some big older bullocks. Breedcow Dynama good.	Need 1-2 and 2+, still small and growing as yearlings. Still growing up to 3+ years.	313C, 321, 322?, 332A	
R314	Lower than NIR 1-2. Breedcow Dynama good.	NIR good 2-3 but probably some big older bullocks. Breedcow Dynama good.	Need 1-2 and 2+, still small and growing as yearlings. Still growing up to 3+ years.	312, 313B, 313C, 322?, 331	
R321	NIR good to 2. Breedcow Dynama good.	NIR low 2-3 and 3+. Breedcow Dynama good to 2.	Need 1-2 and 2+, still small and growing as yearlings. Still growing up to 3+ years.	313E, 322?, 332A	Low number of data points.
R322	Lower than NIR 1-2. Lower than Breedcow	NIR low 2-3 and 3+. Breedcow Dynama good 2-	Need 1-2 and 2+, still small and growing as yearlings.	312, 313C?, 313E, 314?,321?, 331	Good number of data points. Low weight and growth 1-2, may be

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
	Dynama 1-2.	3.	Still growing up to 3+ years.		a function of combining datasets.
R331	Lower than NIR 1-2. Breedcow Dynama good to 1.5 years.	NIR okay 2-3 but high SD. Breedcow Dynama doesn't reach high mature weight but probably should.	Need 1-2 and 2+, still small and growing as yearlings.	312, 313C, 313E, 314, 322, 332A?	Good number of data points. Low wt and growth 1-2, may be a function of combining datasets. 2-3 high SD
R332A	Higher than NIR. Breedcow Dynama good.	NIR low 2-3 and 3+. Breedcow Dynama good 2-3.	Need 1-2 and 2+, still small and growing as yearlings.	313E, 321, 322?, 331	Low number of data points.
R332B	Lower than NIR. Breedcow Dynama good.	NIR okay around 3. Breedcow Dynama good.	Need 1-2 and 2+, still small and growing as yearlings.	311B, 313B	
R711	Similar growth rate but higher average LW than both NIR and Breedcow Dynama (see comments).	Higher growth rate and average LW compared to NIR and Breedcow Dynama (see comments). Does not plateau off as early as NIR and Breedcow Dynama.	Probably need 1-2 and 2+, still small and growing as yearlings. Still growing up to 2+ years. Steers are grown through to bullocks in this region depending on the season.	Unique production environment worthy of own region.	Good number of data points but from a limited number of locations. Most data points are from well-managed herds in the region and averages may be higher than typical for industry "Steers 2+" include large bullocks that are not represented well by NIR curve)
R712	Breedcow Dynama and NIR good.	Similar to NIR and Breedcow Dynama as yearlings but data much higher than NIR at 2+ (these include large bullocks that are not represented well by NIR curve).	Probably need 1-2 and 2+, still small and growing as yearlings. Still growing up to and beyond 2+ years (i.e. towards bullocks).	Unique production environment worthy of own region.	Low number of data points. "Steers 2+" include large bullocks that are not represented well by NIR curve)
R713	Breedcow Dynama good. NIR OK.	Breedcow Dynama okay. Lower than NIR at 1-2 but finish higher than NIR 2-3.	Probably need 1-2 and 2+.	Similar to R714 albeit that growth rate and weight up to 2 years is slightly lower than R714 (probably due to the lead of the steers being finished on floodplain fattening properties in R714).	Good number of data points. Mature weight is reflective of market weight requirement (300-350kg) at 2.5yrs so real data likely to be a truer reflection of situation than Breedcow Dynama or NIR for 2+. Few steers in this region grown through to bullocks.
R714	Breedcow Dynama good. NIR good.	Breedcow Dynama and NIR good for 1-2 yrs. Breedcow Dynama good at 2+ years.	Probably need 1-2 and 2+.	Similar to R713 albeit that growth rate and weight up to 2 years is slightly higher than R713 (probably due to	Low number of data points. Steers in this region not typically grown through to bullocks. Mature weight is reflective of market weight requirement (300-350kg) at

Region	How well do the experimental data match other data sources in the growing phase?	How well do the experimental data match other data sources in the mature phase?	Need for a 1-2 and 2+ class?	Most similar regions	Other comments
				the lead of the steers being finished on floodplain fattening properties in R714).	2.5years.

Recommendations and discussion

We recommend four regions in Queensland and three regions in the Northern Territory (Figure 18) based on the following narratives.

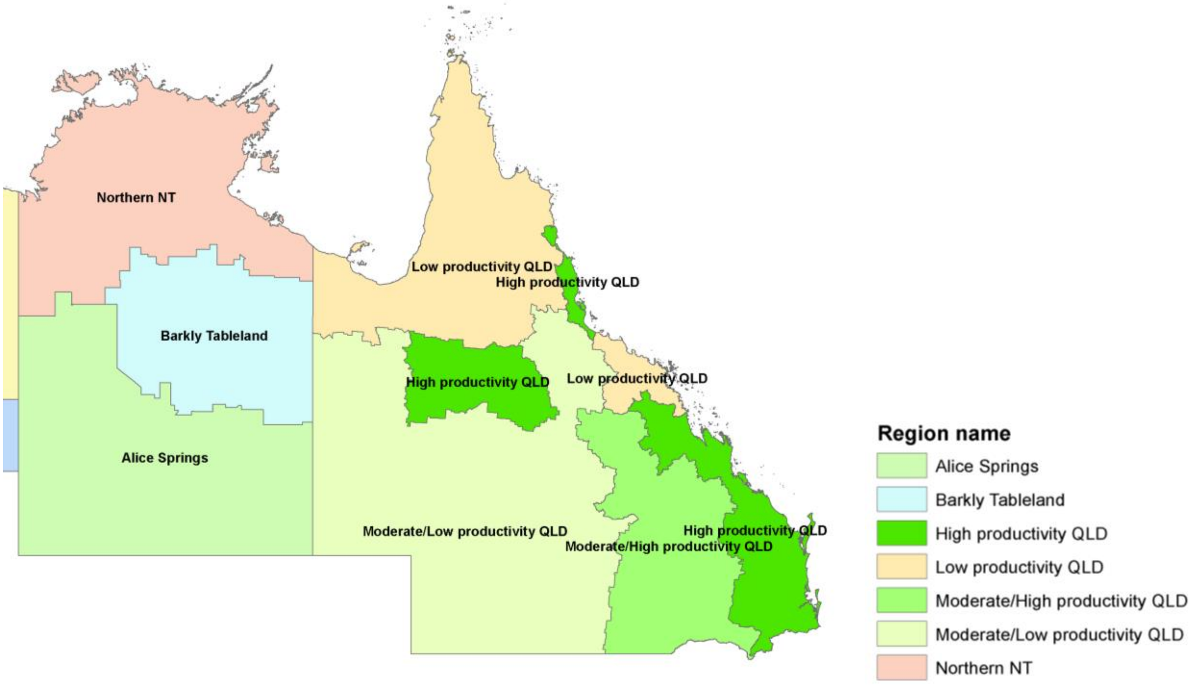


Figure 18: Map of proposed regions

Narrative for regionalisation recommendations - Queensland

Experimental and validated liveweight data from across Queensland was assigned to one of 12 regions defined by CSIRO (Eady & Navarro unpublished) using ABS SA2 region boundaries and representative regional herd models. Liveweight data comparisons for the 12 regions and other mapped biophysical data were used to identify and justify opportunities to combine regions and reduce the number of regions to a maximum of 5-6.

Yet, little visual separation of regions was apparent in the experimental LW data, with the range of regions essentially a continuum of productivity, as can be seen in Figure 19 for female cattle. The least productive region (R311A - Cape York) which stands apart from the other region on Figure 20, represents only 1% of the Queensland cattle herd. Similarly, the two highest productivity regions (R321 - Darling Downs and R332A - Wet Coast and Tableland) represent only 5% of the Queensland cattle herd combined. The other nine regions representing 94% of the Queensland cattle herd span a productivity range of approximate 100 kg LW at any specific age.

We thus recommend that Queensland be split into four sub-regions: High, Moderate/High, Moderate/Low and Low productivity (Table 6 and Figure 18). LW graphs based on the proposed regions are presented in Figure 20.

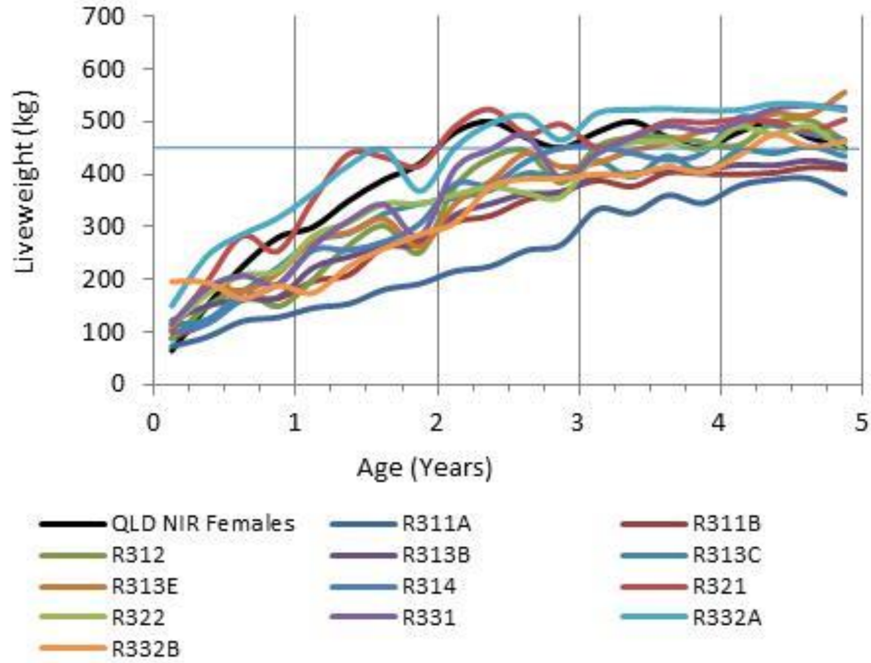


Figure 19: Female cattle experimental liveweight data for 12 regions in Queensland compared to NIR reference data. The 450 kg adult equivalent (AE) line is included on the graph as a comparative reference.

Table 6: Queensland regions allocated to four productivity groups and associated biophysical data.

	High Productivity	Moderate/High Productivity	Moderate/Low Productivity	Low Productivity
CSIRO regions	R313E - Basalt (Dalrymple, Flinders) and Downs R321 - Darling Downs R331 - Coastal speargrass R332A - Wet Coast and Tableland	R322 - Brigalow	R312 - W&SW Qld R313C - Goldfields - eastern half of Dalrymple Shire R314 - Mitchell Downs,Mulga,Desert	R311A - Cape York R311B - Burke and Carpentaria R313B - E.Mareeba Herberton Etheridge R332B - Lower Burdekin and Bowen
% of total Qld herd size	29	31	24	16
Area (% of state)	15	15	45	25
Average annual rainfall (mm)	736	562	358	983
Average SOC (t C/ha to 30cm)	43	40	21	37
Average soil phosphorus (%)	0.041	0.036	0.031	0.023
Average annual pasture productivity (kg/ha/yr)	2618	2333	1082	2298

Due to the productivity continuum across Queensland, we envisage that debate may occur regarding moving a specific region from one proposed sub-regional group to another, based on a specific argument (e.g. recent high adoption of legume planting in a region improving productivity) and 'new' data becoming available. Whilst the recommended regions align with ABS SA2 statistical boundaries for NIR purposes, further consideration may be required when using the LW and LWG reference tables for district- or property-level ERF purposes. At the district or property scale, there will be a range of land types from good productivity (e.g. fertile alluvial flats or brigalow scrub) to poor productivity (e.g. phosphorus deficient stony hills or sandy forest) and, depending on the proportion of these land types and the allocation of specific livestock classes to land types, a particular district or property may be more closely aligned to a neighbouring region.

We thus recommend that scope be given in ERF methodologies to ensure that a particular district or property is able to align with appropriate regional reference tables and benchmarks, based on its relative productivity. This may require verification using measured property/project data.

Queensland High productivity region

The proposed High productivity region represents 29% of the Queensland herd and is characterised by high rainfall and/or fertile soils. The four individual CSIRO regions that combine to form the high productivity region are not located side-by-side. The production systems in these regions generally have the capability to grow steers through to bullock turnoff (depending on market specifications). In this high productivity regional group the lower productivity regions are R313E and R331, representing 83% of the regional herd. High productivity will depend on the location and soils available in a particular district. Steer growing will usually be undertaken on the more fertile soils while breeding will generally occur on the poorer soils.

Female and steer classes of livestock are represented well by the weighted average Breedcow Dynama drawing curve. The NIR over-predicts female and steer LW until 2 years and under-predicts after 2 years. Bulls are represented well.

Queensland Moderate/High productivity region

The Moderate/High productivity region represents 31% of the Queensland herd and is characterised by semi-arid rainfall in central and southern Queensland. The soils are generally moderate to high fertility, however, the soils vary substantially within the region allowing a large mix of fattening and breeding enterprises based on available land types. The region is often recognised by the fertile and productive brigalow land types, however, these land types actually make up less than half the region.

This region differs from the Moderate/Low productivity region due to the presence of fertile land types available on most properties (or property aggregations) enabling high mature cow weights to be reached sooner and steers to be grown faster, depending which paddocks are used and management objectives.

Steers had lower LW data than the NIR and Breedcow Dynama between 1 and 2 years old and then steers 2+ had higher LW than the NIR. Female LW was over-predicted by the NIR and Breedcow Dynama in the 2-3 year age group. Variability in the Bulls 1+ year class makes it hard to determine if they are represented adequately by the NIR.

Queensland Moderate/Low productivity region

The Moderate/Low productivity region represents 24% of the Queensland herd and is characterised by semi-arid to arid rainfall. The soils generally have moderate phosphorous but low soil carbon (likely associated with low rainfall); however, soils vary substantially allowing a large mix of breeding and fattening enterprises based on available soil fertility and rainfall.

All classes of livestock have lower LW than the NIR between 0.75 and 2 years old as steers and 3 years old as females. The average Breedcow Dynama curve slightly over-predicts in the 2-3 year age group for steers and females. Variability in the Bulls 1+ year class makes it hard to determine if they are represented adequately by the NIR.

Queensland Low productivity region

The Low productivity region represents 16% of the Queensland herd and is characterised by reasonable rainfall totals, but poor rainfall distribution, due to the strongly monsoonal climate leading to little or no rainfall for eight months of the year. The Low productivity region, mainly in far north and north-west Queensland is also characterised by infertile soils, especially low in phosphorus. Despite the reasonable rainfall totals over the wet season, pasture quality is generally poor during the long dry season. The regions are adjacent to one another apart from R332B - Lower Burdekin and Bowen located slightly to the south east. These regions are predominately breeding regions exporting yearling steers and heifers to other more productive districts for growing out.

All classes of livestock have much lower LW than the NIR but are represented well by the Breedcow Dynama LW curve.

Narrative for regionalization recommendations – Northern Territory

Based on the comparison of the NIR, Breedcow Dynama and LW datasets, we recommend three regions for the Northern Territory:

- Alice Springs (R711)
- Barkly Region (R712)
- Northern NT (R713 and R714 combined).

A regional justification narrative is presented below. Statistics on the proposed regions and LW graphs based on the proposed regions are presented in Table 7 and Figure 20.

Alice Springs

Located in Central Australia this region is arid to semi-arid. The biophysical environment is starkly different to other regions in Queensland and the NT as a result of low average rainfall, low soil fertility but relatively high quality cured pastures (when present). These features result in highly variable productivity and herd sizes through time. Most cattle from this region are sold to domestic markets and a large proportion of the regional herd is made up of British breeds and cross-breeds.

There were a good number of experimental LW data points but they are from a limited number of locations. Most data points are from well-managed herds in the region and so the averages may be higher than typical for the wider industry.

Average liveweight from the experimental datasets tended to be higher than Breedcow Dynama and NIR. NT DPIF experience suggests that the incremental increase in growth (even in mature cattle) is a true feature of the region and that the NIR and Breedcow Dynama curves are probably under-estimating this. This is particularly the case for older male cattle that are often grown out to bullocks. These are not well represented by the NIR steer curve.

Barkly Region

This region has a wide range of land types and productivity ranging from highly productive black soil Mitchell grass plains in the east to marginal sand-sheet (desert) country in the west. The region has higher cattle densities than region R711 but lower densities than region R713. The climate ranges from semi-arid in the south to subtropical in the north. It is less prone to drought periods, and thus has more stable beef production than region R711. Cattle are marketed domestically or to the live export trade depending on genotype. Composite breeds (that include British, European and *Bos indicus* bloodlines) are mostly sold to Queensland. Producers running pure *Bos indicus* (Brahman) types target the live export trade.

There were a reasonable number of experimental LW data points but this varied with livestock class. Some data points are from very well-managed herds in the region and so some averages may be higher than typical for the wider industry.

Average liveweight from the experimental datasets correlated very well with Breedcow Dynama (and with NIR at younger ages) but tended to be higher than NIR at maturity. NT DPIF experience suggests that the incremental increase in growth (even in mature cattle) is a true feature of the region and that the NIR curves are probably underestimating this. This is particularly the case for older male cattle that are sometimes grown out to bullocks. These are not well represented by the NIR steer curve.

Table 7: Northern Territory allocated regions and associated biophysical data.

	Alice Springs	Barkly Region	Northern NT
CSIRO regions	R711 – Alice Springs	R712 – Barkly Tableland	R713 – Katherine and VRD R714 – Top End and Gulf
% of total NT herd size	16	34	50
Area (% of NT)	42	23	35
Average annual rainfall (mm)	300	429	988
Average SOC (t C/ha to 30 cm)	16	18	33
Average soil phosphorus (%)	0.019	0.019	0.019
Average annual pasture productivity (kg/ha/yr)	474	854	1972

Northern NT

This region has a wide range of land types and productivity ranging from highly productive Mitchell grass plains in the south-west and floodplain properties on the coast, to low productivity rocky escarpment country. Average annual rainfall is high but is restricted to the wet season from October to May. The region is not prone to drought periods, and has relatively stable beef production. Virtually all cattle in the region are marketed to the live export trade. R713 (which includes the Victoria River District) has the highest cattle density in the NT. A large portion of R714 covers Arnhem Land where there is virtually no commercial cattle production.

The NIR, Breedcow Dynama and liveweight datasets for R713 and R714 are very similar to each other and this is why we recommend they be coalesced for the purposes of inventory calculations. Note that only 10% of the NT herd is carried in R714.

There were a reasonable number of experimental LW data points for R713 and a low number for R714. Some data points for R714 are from floodplain properties that would deliver higher average LW and LWG than the wider region. Mature weights in the experimental datasets have a ceiling which reflects the current market requirement imposed by Indonesia (350 kg LW maximum). In the case of steers, the LW and growth rates in R714 were slightly higher than in R713 which is probably due to the industry practice of sending a large number of export cattle to floodplains in R714 for finishing.

Average liveweight from the experimental datasets correlated very well with Breedcow Dynama and reasonably well with NIR. Almost no steers are grown out to bullocks in these regions.

Livestock class recommendations

Based on the visual appraisal of the LW patterns (Figures 17 and 20 and Tables 3 to 5) we recommend 10 livestock classes (Table 1).

For Bulls we recommend two classes: Bull calves 0-1 year old and Bulls 1+ years. This recommendation is despite the fact that there is currently a large jump in liveweight around the one year boundary and subsequent high variability in the Bulls 1+ years data, due to combining <300 kg yearling bulls and 800 kg mature bulls (Figure 1 and Figure 17). Following discussion between the project team and project funders it was decided that the relatively low number of bulls within northern herds did not justify splitting them into additional classes.

For Females we recommend four classes, splitting the NIR 'Cows >2 years' class into 'Heifers 2-3 years' and 'Cows 3+ years'. The proposed 'Cows 3+ years' class would combine the Breedcow Dynama 'Cows 3-4 years', 'Cows 4+ years' and 'Spayed cows'. This recommendation is based on the observation that heifers 2-3 years are still growing in northern Australia and are substantially lighter than mature cows. Management practices have potential to manipulate this class for LW and reproductive performance (e.g. earlier first calving) and thus greenhouse gas emissions performance. For older females in most regions, LW does not seem to increase substantially after 3 years of age. The limited amount of spayed cow LW data accessed was not different to the unspayed cow LW data.

For Steers we recommend four classes, splitting the NIR 'Steers >1' into 'Steers 1-2 years', 'Steers 2-3 years' and 'Steers 3+ years'. The proposed 'Steers 3+ years' class would combine the Breedcow Dynama 'Steers 3-4 years' and 'Steers 4+ years' classes. This recommendation is based on the fact that steers are generally grown for longer in northern Australia with steers grown to large bullocks in some regions and on the more productive land types in less productive regions. Not many steers are kept for more than 4 years. Consideration should be given to develop steers data up to 3+ years for region R712 in the Northern Territory as steers are sometimes grown out to bullocks. The lack of Steers 3+ data in the Northern NT region reflects the current market requirement imposed by Indonesia (350 kg LW maximum), however, if markets change and with the presence of an NT abattoir it may be worthwhile generating Steers 3+ years data.

Ten livestock classes provides a balance between having an excessive number of beef livestock classes on which to collect national data for NIR and other purposes and being able to differentiate livestock management strategies for ERF purposes.

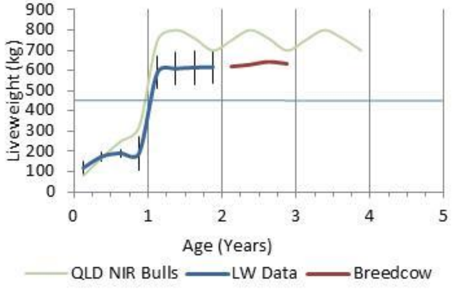
Regional LW reference table

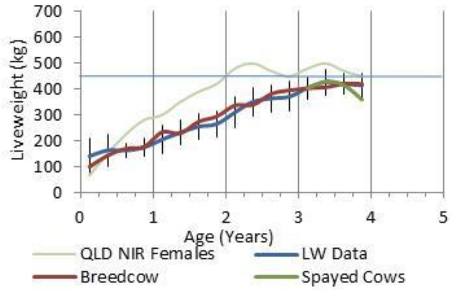
Based on the recommended regions and livestock classes, Figure 20 presents the experimental LW data for bulls, females and steers compared to the NIR reference data and weighted average (based on regional herd number) regional Breedcow Dynama model derived data. Obvious anomalies in the LW data were adjusted to reflect the growth trajectories in a region. Assessment of the similarities and differences between datasets for each livestock class and region were visually assessed and the most appropriate data used to derive the 'LW reference data table' in the same structure are the NIR tables (Table 8; Appendix 4).

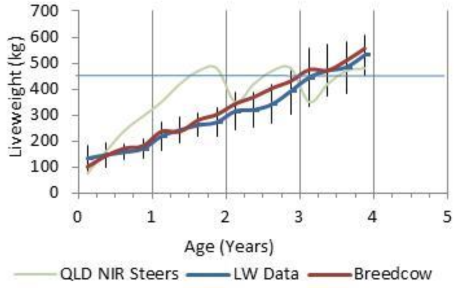
The inventory assumes that cattle present in the first season of the year are present for the whole year. In the Queensland Moderate/High productivity region, Steers >3 are sold half way through the year. To enable the inventory to calculate emissions, it is assumed for the second half of the year that liveweight does not change and LWG is zero. Missing LW data values in the proposed reference table occurs where that class of livestock has been sold off property during the previous year (NT Barkly and Northern NT).

Regional LWG reference table

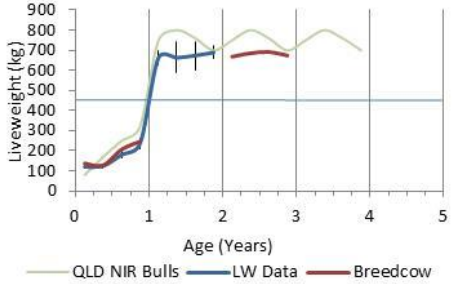
Following the generation of the regional seasonal LW reference tables for each class (Appendix 4), regional seasonal LWG was calculated by subtracting the estimated liveweight at the start of each season (derived by averaging the two seasonal LW values) from the estimate of liveweight at the end of the season and dividing by 91 days (season length). The proposed LWG data reference tables are presented in Appendix 4.

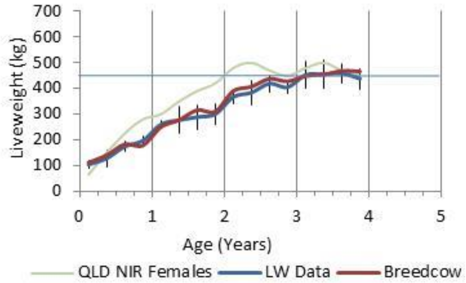


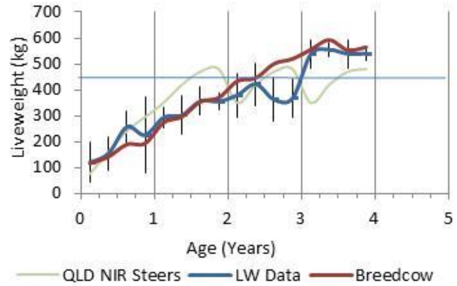




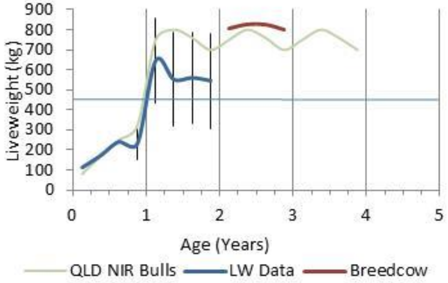
Qld Low

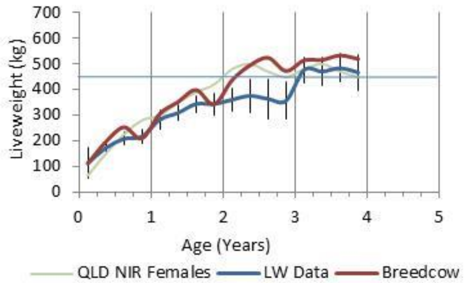


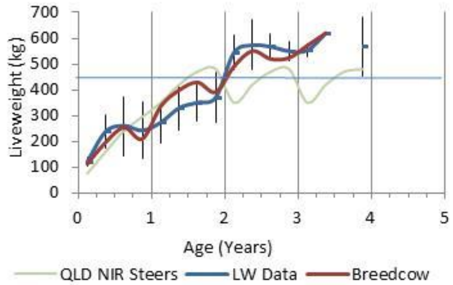




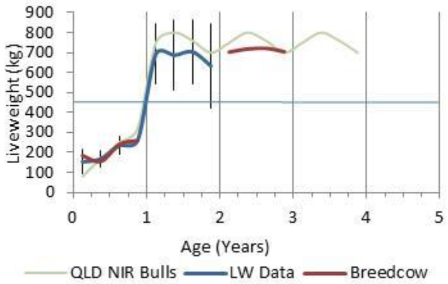
Qld Moderate/Low

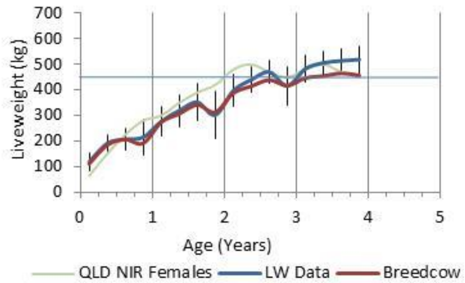


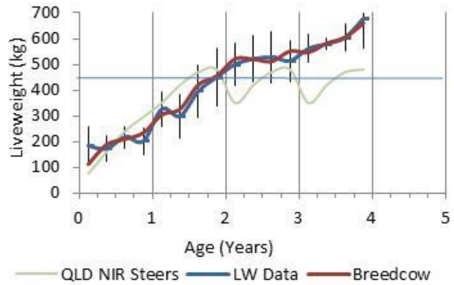




Qld Moderate/High







Qld High

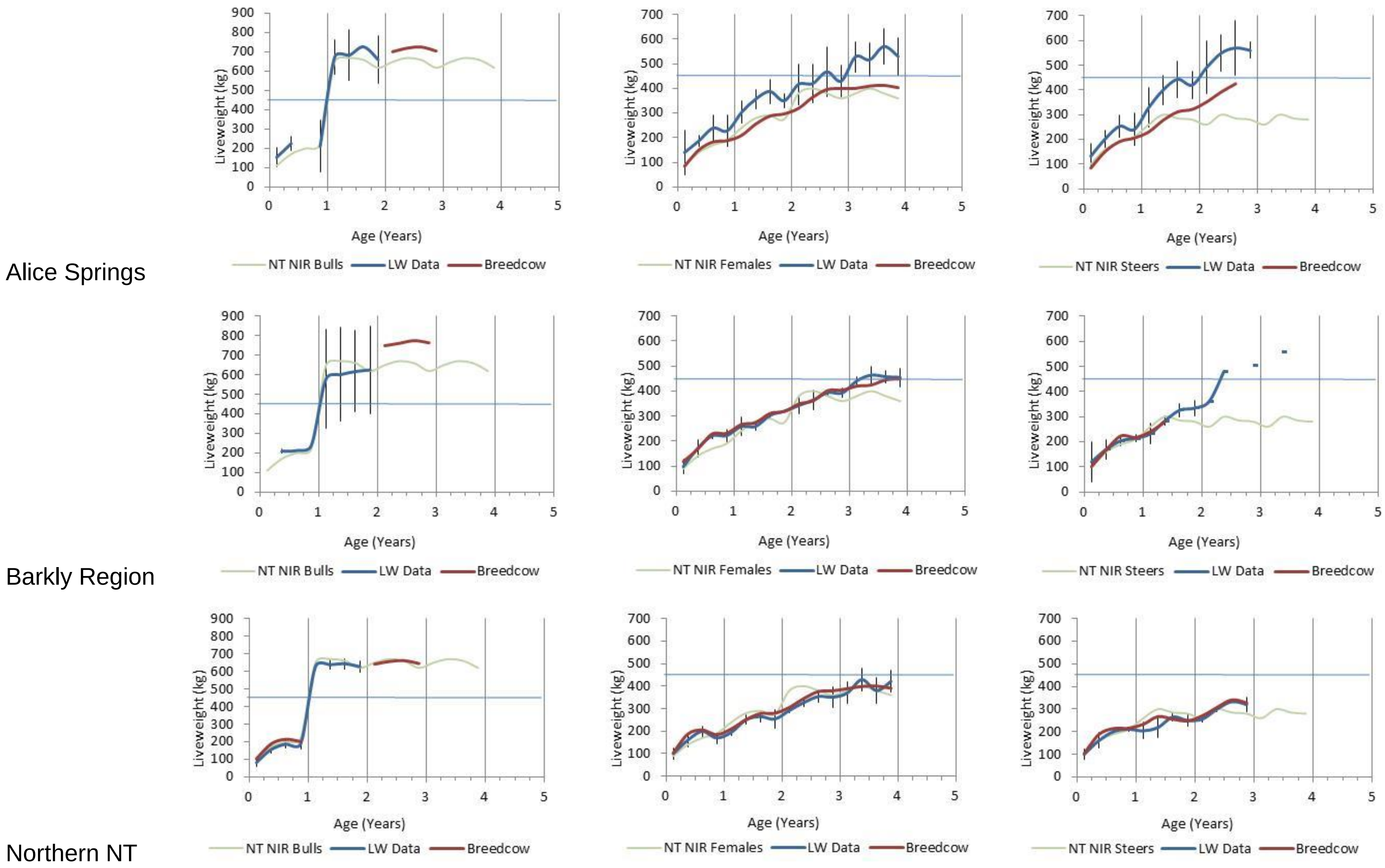


Figure 20: Average seasonal liveweight data for bulls (left), females (centre) and steers (right) compared to the NIR reference data and weighted average Breedcow Dynama data for the proposed regions. Error bars are standard deviation (SD). The blue 450 kg adult equivalent (AE) line is included on the graph as a comparative reference.

Table 8: Data and considerations for generating the proposed LW reference tables

State	Region	Bulls	Females	Steers
Qld	Low productivity	Bulls <1 used LW data as generally lower than NIR. Bulls >1 used Breedcow Dynama, LW data high variation, lower than NIR.	Used Breedcow Dynama, very similar to LW data, lower than NIR.	Used LW data, similar to Breedcow Dynama, but slightly lower 2-3 years. Much lower than NIR.
Qld	Moderate /Low productivity	Bulls <1 used LW data, similar to Breedcow Dynama and generally lower than NIR. Bulls >1 used Breedcow Dynama, LW data high variation, lower than NIR.	Used Breedcow Dynama, very similar to LW data, lower than NIR.	Used Breedcow Dynama, similar to LW data apart from a couple of values 2.5-3 years.
Qld	Moderate/High productivity	Bulls <1 used LW data, similar to NIR. Bulls >1 used Breedcow Dynama from Moderate/Low, LW data highly variable, NIR and Moderate/High Breedcow Dynama too high.	Used LW data, lower than Breedcow Dynama and NIR, probably reflects cows grazed on poorer land types in the region.	Used LW Data, lower than Breedcow Dynama year 1-2.
Qld	High productivity	Bulls <1 used LW data, similar to NIR and Breedcow Dynama. Bulls >1 used Breedcow Dynama, LW data highly variable, NIR similar.	Used LW data, similar to Breedcow Dynama but slightly higher mature weights, 1-2.5 years lower than NIR.	Used Breedcow Dynama, very similar to LW data and more steadily continually growing without going backwards.
NT	Alice Springs	Bulls <1 used NIR data. LW data similar to NIR, no Breedcow Dynama data. Bulls >1 used Breedcow Dynama as it was more consistent with the growth trajectory than NIR.	Used average of Breedcow Dynama and LW data, actual LW data obtained probably higher than average performance for region.	Used average of Breedcow Dynama and LW data, actual LW data obtained probably higher than average performance for region.
NT	Barkly Region	Bulls <1 used NIR data. LW data similar to NIR but very few data points, no Breedcow Dynama data. Bulls >1 used NIR as it was consistent with the growth trajectory.	Used average of Breedcow Dynama and LW data, NIR mature weights too low	Used average of Breedcow Dynama and LW data, NIR mature weights far too low.
NT	Northern NT	Bulls <1 used NIR data. LW data and Breedcow Dynama similar to NIR. Bulls >1 used NIR as it was consistent with the growth trajectory.	Used average of Breedcow Dynama and LW data, NIR weights too high for 2-3 years.	Used average of Breedcow Dynama and LW data, NIR weights too high for 1-2 years and too low for mature weights.

Regional pasture DMD and CP reference tables

Over 4500 pasture quality data records for DMD and CP were collated for Queensland and the Northern Territory. A comparison of the regional pasture quality data and the NIR for Queensland and the Northern Territory are presented in Figures 21 and 22.

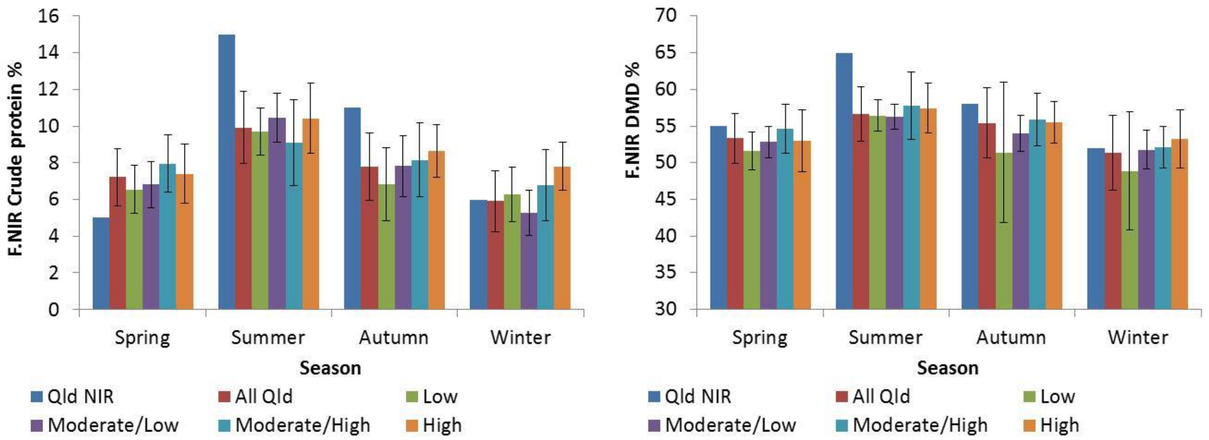


Figure 21: Regional pasture quality data (CP - left and DMD-right) and the NIR for Queensland

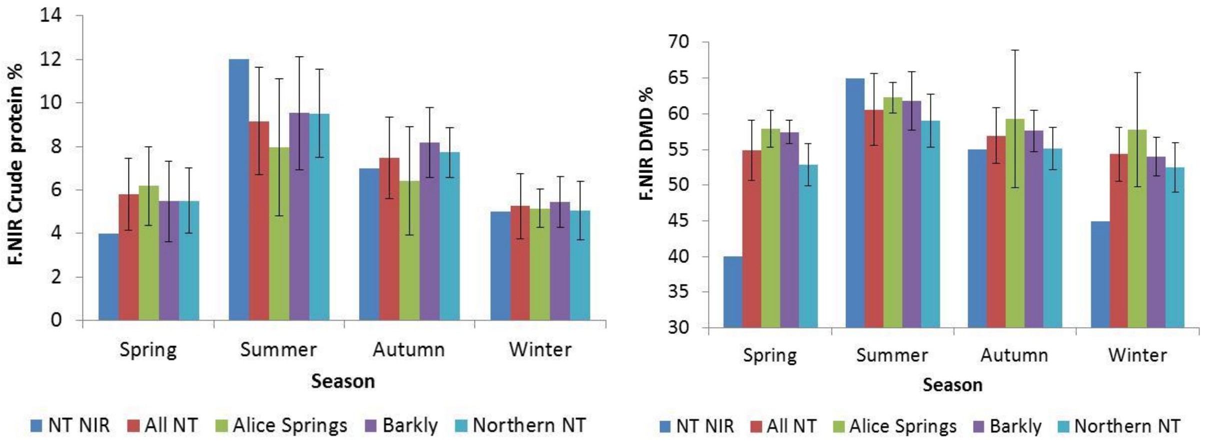


Figure 22: Regional pasture quality data (CP - left and DMD-right) and the NIR for Northern Territory

For both DMD and CP in Queensland and the Northern Territory, the data overlaps between regions within each season (Figures 21 and 22). The State/Territory mean seasonal values differ from the NIR value in some seasons. We thus recommend changing the NIR reference tables to reflect the mean State/Territory values (Appendix 4).

Allocating proportion of regional herd number to each livestock class

The proportion of the regional herd (not including feedlot cattle) in each livestock class and proportion of Cows >2 lactating is presented in Appendix 5.

The number of weaners produced was used to estimate the proportion of the Cows >2 (Cows 2-3 plus Cows >3) that were lactating for the full period. Note that in some regions, weaners were 'sold' part way through the year (e.g. NT Barkly), so the number of weaners for the full year will not equal the number of cows lactating. In the proposed Queensland Moderate/High productivity region, yearly mating occurs so the proportion of Cows >2 lactating appears high (1.0), but will 'balance' the yearling heifers lactating (Cows 1-2). The proportion lactating in the Queensland Moderate/High productivity region including Cows 1-2, 2-3 and >3 was 0.726. The average calving date is assumed to be the start of Summer (1^{st} December) for Queensland and NT, so the 1^{st} lactating season is Summer.

Feedlot cattle were assumed to be split between 2 regions: Queensland High productivity (75% of feedlot cattle) and Queensland Moderate/High productivity region (25% of feedlot cattle). When applying the proportion of cattle numbers in each class for each region, the number of feedlot cattle must first be subtracted before applying the class proportions.

Lessons learnt from data collation

Data collation relies on:

- strong relationships with researchers and their teams to access data
- follow-up and perseverance to ensure data is received
- significant time to manipulate the data into the form and format required
- significant time to follow-up on important missing data (e.g. GPS location)

Lessons learnt include:

- Projects like this cannot be rushed; collaboration takes time. Collation of historical data is time consuming and was not always a high priority for people not directly involved in the project.
- The process requires iterative changes as it progresses. Many issues regarding data form and ancillary data arose through the process. Data entry templates need to be rigid to ensure smooth integration into the database but also adaptable which can lead to significant delays and work for data managers.
- Each data extraction requires significant data checking to ensure the database queries are working as expected.
- Due to the resource-intensive nature of such an exercise, it is important to ensure that the data will be usable for other purposes.

Assumptions, issues and caveats

Source of the data

- Much of the data are from research trials and research stations. Data from these herds may not represent wider industry performance (e.g. better or worse genetics, better quality pastures etc.).
- Significant quantities of other data would be held by corporate pastoral companies which we did not have access to. Access to corporate pastoral company data in more remote regions would help to provide greater accuracy for LW, LWG, CP and DMD data in those regions.

Season of calving

- We have assumed the start of summer (i.e. 1^{st} December) is the average birth date of beef cattle in Queensland and the Northern Territory. We felt this was reasonable as many businesses target slightly earlier calving but the significant numbers of late calves would bring the average calving date later. This may not be the case for all regions and all production systems and may have implications for early calf data (i.e. those that were born in Spring). The variability in calving date may contribute to Spring LW data variability (e.g. calves born in November = low weight for one month in Spring, but by the end of the year have two high weights in Spring).
- We have not accounted for the spread of calving (1st and 2nd round musters) which occurs in many northern herds that do not have controlled mating.

Female weight loss at calving

- We have not accounted for female weight loss at calving. We have used actual LW provided. This may have implications for LWG calculation spanning the calving period.
- We have not corrected the data for foetus weight.
- We have not accounted for wet and dry cows in the herd. They have been amalgamated together for the mob average.

Mix of land types within a region, districts and properties (mix can vary between properties within a region).

- Due to the productivity continuum in regions and land types across northern Australia, we recommend that scope be given to ensure that a particular district or property is able to align with appropriate regional reference tables and benchmarks, based on its relative productivity when used for ERF purposes.
- The location and land type where data was collected will impact regional LW data (e.g. most data from a region may be collected on high productivity land types, e.g. alluvial flats for growing out steers).
- There is a mix of land types within ABS SA2 regions with some similarities between neighbouring regions, which could be argued should be allocated to one regional grouping or another. An example of this is the Broundsound-Nebo SA2 region at the northern end of the R331 region in coastal south-east Queensland (Figure 2). The Broadsound-Nebo SA2 region contains significant areas of coastal speargrass and coastal range country land types, but also extends inland encompassing significant areas of Brigalow and Box country (Figure 12). It could be argued that this region may be better aligned to the neighbouring R322 Brigalow region.

Non grazing land within a region (e.g. defence or indigenous land) having low productivity and/or low cattle numbers.

- Our regional data for a region is focussed on grazing land. Large areas of very poor fertility or arid country with no cattle (e.g. desert country in the NT) would not be represented by the Alice Spring reference tables.

Acknowledgements

This project could not have happened without the cooperation of many people who have undertaken the research and stored the experimental data over many years.

In particular we would like to thank Geoffry Fordyce, Kieren McCosker, Tim Schatz, Trudi Oxley, Chris Materne, Gonzalo Mata, Ed Charmley, Peter O'Reagain, Paul Jones, Richard Silcock, Trevor Hall, Jocelyn Coventry, Michael Sullivan, Tim Grant, Neil MacDonald, Robyn Cowley, Trisha Cowley and Whitney Dollemore.

References

AusVet (2006) A review of the structure and dynamics of the Australian beef cattle industry. AusVet Animal Health Services.

BoM (2015) Bureau of Meteorology. Australian Water Availability Project (http://www.bom.gov.au/jsp/awap/). Accessed 4 June 2015.

Carter, J.O., Bruget, D., Hassett, R., Henry, B., Ahrens, D., Brook, K., Day, K., Flood, N., Hall, W., McKeon, G., and Paull, C. (2003) Australian Grassland and Rangeland Assessment by Spatial Simulation (AussieGRASS), in R.S.a.I. Partridge (ed.), Science for Drought, Department of Primary Industries Queensland, pp. 152-159.

Carter, J.O., Flood, N.F., Danaher, T., Hugman, P., Young, R., Duncalfe, F., Barber, D., Flavel, R., Beeston, G., Mlodawski, G., Hart, D., Green, D., Richards, R., Dudgeon, G., Dance, R., Brock, D., and Petty, D. (1996) Development of a National Drought Alert Strategic Information System : Development of data rasters for model inputs. Vol. 3 Final Report on QPI 20 to Land and Water Resources Research and Development Corporation, Canberra. 76 pp.

DAF (2015) Breedcow Dynama regional templates. https://www.daf.qld.gov.au/business-trade/business-and-trade-services/breedcow-and-dynama-software. Accessed 20 April 2015.

DIICCSRTE (2013) AUSTRALIAN NATIONAL GREENHOUSE ACCOUNTS National Inventory Report 2011. Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)

Havard, G., Eady, S., Bray, S., and Cruypenninck, H. (2013) A method to refine the geographical scale of greenhouse gas emissions for the northern beef industry. In 'NBRUC.' Cairns)

McGowan, M., Fordyce, G., O'Rourke, P., Barnes, T., Morton, J., Menzies, D., Jephcott, S., McCosker, K., Smith, D., Perkins, N., Marquart, L., Newsome, T., and Burns, B. (2014) Northern Australian beef fertility project: CashCow Final Report Project B.NBP.0382. Meat & Livestock Australia Limited, NORTH SYDNEY NSW.

McLean, I., Holmes, P., and Counsell, D. (2014) The Northern beef report 2013 Northern beef situation analysis. Meat and Livestock Australia, North Sydney NSW.

Sparkes, J., Nikolova, S., Yainshe, T.A., Walcot, T.J., Gray, J., Heyhoe, E., Bruce, S., and White, S. (2011) Options for on-farm mitigation of greenhouse gases in Australia. Australian Bureau of Agriculture and Resource Economics and Sciences, Canberra, ACT.

Tothill, J.C., and Gillies, C. (1992) The pasture lands of northern Australia - their condition, productivity and sustainability. Tropical Grassland Society of Australia. Occassional Publication 5.

Viscarra Rossel, R., Webster, R., Bui, E., and Baldock, J. (2014a) Baseline map of Australian soil organic carbon stocks and their uncertainty. v2. CSIRO. Data Collection. 10.4225/08/556BCD6A38737

Viscarra Rossel, R., Chen, C., Grundy, M., Searle, R., Clifford, D., Odgers, N., *et al*. (2014b): Soil and Landscape Grid National Soil Attribute Maps - Total Phosphorus (3" resolution) - Release 1. v4. CSIRO. Data Collection. 10.4225/08/546F617719CAF

Appendices

Appendix 1: ABS SA2 regions assigned to each Breedcow Dynama herd model region

Eady & Navarro unpublished

	ABS SA2 region
R311A	Aurukun, Cape York, Kowanyama – Pormpuraaw, Northern Peninsula, Torres Torres Strait Islands, Weipa
R311B	Carpentaria
R312	Mount Isa, Mount Isa Region, Far Central West, Far South West
R313B	Herberton, Kuranda, Mareeba, Croydon – Etheridge, Tablelands
R313C	Charters Towers, Dalrymple
R313E	Northern Highlands
R314	Barcaldine – Blackall, Charleville, Longreach
R321	Crows Nest – Rosalie, Jondaryan, Millmerran, Pittsworth, Wambo, Clifton – Greenmount, Southern Downs – East, Southern Downs – West, Stanthorpe, Stanthorpe Region, Warwick, Cambooya – Wyreema, Darling Heights, Drayton – Harristown, Gowrie (Qld), Highfields, Middle Ridge, Newtown (Qld), North Toowoomba – Harlaxton, Rangeville, Toowoomba – Central, Toowoomba – East, Toowoomba – West, Wilsonton
R322	Balonne, Chinchilla, Goondiwindi, Inglewood – Waggamba, Miles – Wandoan, Roma, Roma Region, Tara, Central Highlands – East, Central Highlands – West, Emerald, Banana, Biloela, Mount Morgan, Clermont, Moranbah
R331	Alexandra Hills, Belmont – Gumdale, Birkdale, Capalaba, Thorneside, Wellington Point, Cleveland, Ormiston, Redland Bay, Redland Islands, Sheldon - Mount Cotton, Thornlands, Victoria Point, Brisbane Port – Lytton, Manly – Lota, Manly West, Murarrie, Tingalpa, Wakerley, Wynnum, Wynnum West – Hemmant, Bald Hills, Bridgeman Downs, Carseldine, Everton Park, McDowall, Aspley, Chermside, Chermside West, Geebung, Kedron - Gordon Park, Stafford, Stafford Heights, Wavell Heights, Boondall, Brisbane Airport, Eagle Farm – Pinkenba, Northgate – Virginia, Nudgee – Banyo, Nundah, Bracken Ridge, Brighton (Qld), Deagon, Sandgate – Shorncliffe, Taigum – Fitzgibbon, Zillmere, Camp Hill, Cannon Hill, Carina, Carina Heights, Carindale, Annerley, Coorparoo, Fairfield - Dutton Park, Greenslopes, Holland Park, Holland Park West, Woolloongabba, Yeronga, Eight Mile Plains, Macgregor (Qld), Mansfield (Qld), Mount Gravatt, Rochedale – Burbank, Upper Mount Gravatt, Wishart, Coopers Plains, Moorooka, Robertson, Salisbury – Nathan, Tarragindi, Algester, Calamvale – Stretton, Pallara – Willawong, Parkinson – Drewvale, Rocklea - Acacia Ridge, Kuraby, Runcorn, Sunnybank, Sunnybank Hills, Jindalee - Mount Ommaney, Middle Park - Jamboree Heights, Riverhills, Seventeen Mile Rocks - Sinnamon Park, Westlake, Bellbowrie – Moggill, Brookfield - Kenmore Hills, Chapel Hill, Fig Tree Pocket, Kenmore, Pinjarra Hills – Pullenvale, Chelmer – Graceville, Corinda, Indooroopilly, Sherwood, St Lucia, Taringa, Enoggera, Enoggera Reservoir, Keperra, Mitchelton, Mount Coot-tha, The Gap, Upper Kedron - Ferny Grove, Brisbane City, Fortitude Valley, Highgate Hill, Kangaroo Point, New Farm, South Brisbane, Spring Hill, West End, Balmoral, Bulimba, East Brisbane, Hawthorne, Morningside - Seven Hills, Norman Park, Albion, Alderley, Ascot, Clayfield, Grange, Hamilton (Qld), Hendra, Kelvin Grove – Herston, Newmarket, Newstead - Bowen Hills, Wilston, Windsor, Wooloowin – Lutwyche, Ashgrove, Auchenflower, Bardon, Paddington – Milton, Red Hill (Qld), Toowong, Agnes Water - Miriam Vale, Boyne Island - Tannum Sands, Callemondah, Clinton - New Auckland, Gladstone, Gladstone Hinterland, Kin Kora - Sun Valley, South Trees, Telina – Toolooa, West Gladstone, Berserker, Bouldercombe, Emu Park, Frenchville - Mount Archer, Glenlee – Rockyview, Gracemere, Lakes Creek, Norman Gardens, Park Avenue, Parkhurst – Kawana, Rockhampton – West, Rockhampton City, Rockhampton Region – East, Rockhampton Region – North, Rockhampton Region – West, Shoalwater Bay, The Range – Allenstown, Yeppoon, Broadbeach Waters, Burleigh Heads, Burleigh Waters, Mermaid Beach – Broadbeach, Mermaid Waters, Miami, Currumbin – Tugun, Currumbin Waters, Elanora, Palm Beach, Arundel, Biggera Waters, Coombabah, Labrador, Paradise Point – Hollywell, Runaway Bay, Guanaba – Springbrook, Tamborine – Canungra, Currumbin Valley – Tallebudgera, Mudgeeraba – Bonogin, Reedy Creek – Andrews, Carrara, Highland Park, Nerang - Mount Nathan, Pacific Pines, Gaven, Worongary – Tallai, Coomera, Helensvale, Hope Island, Jacobs Well – Alberton, Ormeau – Yatala, Oxenford – Maudsland, Pimpama, Upper Coomera - Willow Vale, Clear Island Waters, Merrimac, Robina, Varsity Lakes, Ashmore, Molendinar, Parkwood, Southport, Benowa, Bundall, Main Beach, Surfers Paradise, Darra – Sumner, Durack, Forest Lake – Doolandella, Inala – Richlands, Oxley (Qld), Wacol, Boonah, Esk, Lake Manchester - England Creek, Lockyer Valley – East, Lowood, Rosewood, Brassall, Bundamba, Churchill – Yamanto, Ipswich – Central, Ipswich – East, Ipswich – North, Karalee - Barellan Point,

	Karana Downs, Leichhardt - One Mile, North Ipswich – Tivoli, Raceview, Ripley, Riverview, Bellbird Park – Brookwater, Camira – Gailes, Carole Park, Collingwood Park – Redbank, Goodna, New Chum, Redbank Plains, Springfield, Springfield Lakes, Beaudesert, Beenleigh, Eagleby, Edens Landing – Holmview, Mount Warren Park, Wolffdene - Bahrs Scrub, Boronia Heights - Park Ridge, Browns Plains, Chambers Flat - Logan Reserve, Crestmead, Greenbank Military Camp, Hillcrest, Marsden, Munruben - Park Ridge South, Regents Park - Heritage Park, Greenbank, Jimboomba, Logan Village, Bethania – Waterford, Cornubia – Carbrook, Loganholme - Tanah Merah, Loganlea, Shailer Park, Waterford West, Daisy Hill, Kingston, Logan Central, Rochedale South – Priestdale, Slacks Creek, Springwood, Underwood, Woodridge, Broadsound – Nebo, Beachmere - Sandstone Point, Bribie Island, Burpengary – East, Caboolture, Caboolture – South, Elimbah, Morayfield – East, Wamuran, Kilcoy, Woodford - D'Aguilar, Burpengary, Deception Bay, Morayfield, Narangba, Upper Caboolture, Clontarf, Margate - Woody Point, Redcliffe, Rothwell - Kippa-Ring, Scarborough – Newport, Albany Creek, Cashmere, Dayboro, Eatons Hill, Hills District, Samford Valley, Dakabin – Kallangur, Murrumba Downs – Griffin, North Lakes - Mango Hill, Bray Park, Lawnton, Petrie, Strathpine – Brendale, Buderim – North, Buderim – South, Mountain Creek, Sippy Downs, Aroona – Currimundi, Buddina – Minyama, Caloundra - Kings Beach, Caloundra – West, Golden Beach - Pelican Waters, Moffat Beach - Battery Hill, Parrearra – Warana, Wurtulla – Birtinya, Coolum Beach, Marcoola – Mudjimba, Maroochydore – Kuluin, Mooloolaba - Alexandra Headland, Bli Bli, Diddillibah – Rosemount, Eumundi – Yandina, Nambour, Noosa Hinterland, Noosa Heads, Noosaville, Peregian, Sunshine Beach, Tewantin, Beerwah, Caloundra Hinterland, Glass House Mountains, Landsborough, Maroochy Hinterland, Palmwoods, Gatton, Lockyer Valley – West, Ashfield – Kepnock, Bargara - Burnett Heads, Branyan – Kensington, Bundaberg, Bundaberg East – Kalkie, Bundaberg North – Gooburrum, Bundaberg Region – North, Bundaberg Region – South, Millbank – Avoca, Svensson Heights – Norville, Walkervale - Avenell Heights, Gayndah – Mundubbera, Gin Gin, Kingaroy, Kingaroy Region – North, Kingaroy Region – South, Monto – Eidsvold, Nanango, North Burnett, Cooloola, Gympie – North, Gympie – South, Gympie Region, Kilkivan, Booral - River Heads, Craignish - Dundowran Beach, Pialba - Eli Waters, Point Vernon, Torquay - Scarness – Kawungan, Urangan – Wondunna, Burrum – Fraser, Granville, Maryborough (Qld), Maryborough Region – South, Tinana
R332A	Brinsmead, Clifton Beach - Kewarra Beach, Freshwater – Stratford, Redlynch, Trinity Beach – Smithfield, Yorkeys Knob - Machans Beach, Bentley Park, Cairns City, Earlville - Bayview Heights, Edmonton, Gordonvale – Trinity, Kanimbla – Mooroobool, Lamb Range, Manoora, Manunda, Mount Sheridan, Westcourt – Bungalow, White Rock, Whitfield - Edge Hill, Woree, Babinda, Innisfail, Johnstone, Tully, Wooroonooran, Yarrabah, Daintree, Port Douglas, Atherton, Malanda – Yungaburra, Ingham, Ingham Region, Palm Island, Northern Beaches
R332B	Bowen, Collinsville, Andergrove – Beaconsfield, East Mackay, Eimeo - Rural View, Eungella Hinterland, Mackay, Mackay Harbour, Mount Pleasant – Glenella, North Mackay, Ooralea - Bakers Creek, Pioneer Valley, Sarina, Seaforth – Calen, Shoal Point – Bucasia, Slade Point, South Mackay, Walkerston – Eton, West Mackay, Airlie – Whitsundays, Cape Conway, Proserpine, Ayr, Burdekin, Aitkenvale, Annandale, Belgian Gardens – Pallarenda, Bohle Plains, Condon – Rasmussen, Cranbrook, Deeragun, Douglas, Garbutt - West End, Gulliver - Currajong – Vincent, Heatley, Hermit Park – Rosslea, Hyde Park – Pimlico, Kelso, Kirwan – East, Kirwan – West, Magnetic Island, Mount Louisa, Mundingburra, Oonoonba, South Townsville - Railway Estate, Townsville – South, Townsville City - North Ward, Wulguru - Roseneath
R711	Charles, East Side, Flynn (NT), Larapinta, Mount Johns, Petermann – Simpson, Ross, Sandover – Plenty, Tanami, Yuendumu - Anmatjere
R712	Barkly, Tennant Creek
R713	Elsey, Katherine, Victoria River
R714	Darwin Airport, Darwin City, East Point, Fannie Bay - The Gardens, Larrakeyah, Ludmilla - The Narrows, Parap, Stuart Park, Woolner - Bayview – Winnellie, Alawa, Anula, Berrimah, Brinkin – Nakara, Buffalo Creek, Charles Darwin, Coconut Grove, East Arm, Jingili, Karama, Leanyer, Lyons (NT), Malak – Marrara, Millner, Moil, Nightcliff, Rapid Creek, Tiwi, Wagaman, Wanguri, Wulagi, Howard Springs, Humpty Doo, Koolpinyah, Virginia, Weddell, Bakewell, Driver, Durack - Marlow Lagoon, Gray, Moulden, Palmerston – North, Palmerston – South, Rosebery – Bellamack, Woodroffe, Alligator, Daly, Thamarrurr, Tiwi Islands, West Arnhem, Anindilyakwa, East Arnhem, Gulf

Appendix 2: Data references and project name

LW and LWG references and project name

Reference	Project Name
Agnew (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 261-266.	Liveweight performance of 2-3 year-old Brahman cross steers grazing Highworth dolichos 1991-95 (PDS)
Anon. (1991). Brian Pastures Annual Report 1991, p33, 1992, p28.	Reducing dry season weight loss with trenbolone acetate
Bawden (1996). Producer Demonstration Sites Project Report 1995-96, pp 165-168.	Using EBV values to increase liveweight gain of steers 1993-96 (PDS)
Beef CRC Program 4, Research Sites Monthly Reports, 2006-2011.	Beef CRC Northern Industry project 4.1.3b Improving Female Reproductive Performance Beef CRC for Cattle and Beef Quality (CRC II) Sub-program 2 – Project 2.3 - Links between the genetics of beef quality and components of herd profitability in northern Australia
Bishop *et al*. (1993). Proc. XVII International Grassland Congress 1993, pp 2236-2237. Bishop *et al*. (1996). Producer Demonstration Sites Final Report 1996. DAQ.M001, Part 4, pp 1-4.	Annual liveweight gain of steers grazing virgin poplar box woodland 1983-88 (PDS)
Bolam, M., Triglone, T. & Petty, S. (1998). Comparison of two cultivars of *Leucaena leucocephala* in a rotational grazing system. *Proc. Aust. Soc. Anim. Prod*. 22:356.	Comparison of two cultivars of *Leucaena leucocephala* in a rotational grazing system
Bortolussi, G., Hodgkinson, J., Holmes, C., McIvor, J. & Coffey, S. (1999). Report on the Northern Australian Beef Industry Survey Activity-Barkly Region, CSIRO Division of Tropical Agriculture, Queensland, Australia.	Report on the Northern Australian Beef Industry Survey Activity- Barkly Region Report
Bortolussi, G., Hodgkinson, J., Holmes, C., McIvor, J. & Coffey, S. (1999). Report on the Northern Australian Beef Industry Survey Activity-Darwin- Douglas Daly Region, CSIRO Division of Tropical Agriculture, Queensland, Australia.	Report on the Northern Australian Beef Industry Survey Activity- Darwin-Douglas Daly Region Report
Bortolussi, G., Hodgkinson, J., Holmes, C., McIvor, J. & Coffey, S. (1999). Report on the Northern Australian Beef Industry Survey Activity-Katherine Region, CSIRO Division of Tropical Agriculture, Queensland, Australia.	Report on the Northern Australian Beef Industry Survey Activity- Katherine Region Report
Bortolussi, G., Hodgkinson, J., Holmes, C., McIvor, J. & Coffey, S. (1999). Report on the Northern Australian Beef Industry Survey Activity-Victoria River District Region, CSIRO Division of Tropical Agriculture, Queensland, Australia.	Report on the Northern Australian Beef Industry Survey Activity- Victoria River District Region Report
Clarke (1991). Beef Cattle Production in South-West Queensland. Queensland Dept. of Primary Industries. Brisbane. pp 33-36.	Response to supplementation of cows and calves grazing a predominantly mulga diet
Clarke (1991). Beef Cattle Production in South-West Queensland. Queensland Dept. of Primary Industries. Brisbane. pp 33- 36.	Effect of a nitrogen, phosphorus and sulphur supplement fed via drinking water on liveweight gain of steers grazing a predominantly mulga diet
Clarke (1991). Beef Cattle Production in South-West Queensland. Queensland Dept. of Primary Industries. Brisbane. pp 33-36.	Response to supplementation of Hereford steers grazing a predominantly mulga diet
Clarke, M.R. & Wythes, J.R. (1988). Effect of short- and long-acting growth promotants on grazing beef cattle in south-west Queensland. *The Australian Rangeland Journal* 10, 30–33.	Effect of long-acting and short-acting growth promotants on steers grazing channel country in south-west Queensland 1983-85
Clem *et al*. (1993). Proc. XVII Int. Grassl. Cong. 1993, pp 2023-2025. Esdale (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 213-217.	Beef production from commercial leucaena pastures 1990-93
Coates, D.B. (1994). The effect of phosphorus as fertiliser or supplement on pasture and cattle productivity in the semi-arid tropics of north Queensland. *Tropical Grasslands*. 28: 90-108.	The effect of phosphorus as fertiliser or supplement on cattle productivity in the semi-arid tropics of north Queensland 1981-90
Coates, D.B., Miller, C.P., Hendricksen, R.E. & Jones, R.J. (1997). Stability and productivity of *Stylosanthes* pastures in Australia II. Animal production from *Stylosanthes* pastures *Tropical Grasslands.* 31: 494-502.	Animal production from stylo pastures at four sites in northern Australia
Cowley, T. (2014) Boosting steer growth: Comparing the effectiveness of HGP strategies on Hayfield Station. Final	Boosting steer growth: Comparing the effectiveness of HGP strategies on Hayfield Station

Report. Meat & Livestock Australia Limited. North Sydney.	
DAF 2015 Beef CRC Breedcow Dynama regional templates http://futurebeef.com.au/topics/business-management/representative-herd-templates-for-northern-australia/ accessed 1 June 2015	Beef CRC Breedcow Dynama regional templates
Bray, S., Walsh, D., Rolfe, J., Broad, K., Phelps, D., Cowley, R., Daniels, B., Emery, T., English, B., Ffoulkes, D., Gowen, R., Gunther, R., Hegarty, E., Houston, I., McGrath, T., Pahl, L., Shotton, P., Sneath, R., and Whish, G. (2015) Northern grazing carbon farming – integrating production and greenhouse gas outcomes 1&2. Climate Clever Beef Final Report. Department of Agriculture and Fisheries, Rockhampton, Queensland.	Climate Clever Beef. Breedcow Dynama herd modelling
Dixon (1998). Task 1, Project DAQ.098, Final Report, MLA September 1998, pp 48-51.	Effect of high-urea dry lick supplements fed during the dry season on liveweight and subsequent fertility of first-calf cows 1996-97
Doust, A., Hearnden, M., Adams, M. & Savage, D. (2002). Avon Downs indicator herd project- McCullochs paddock. Final Report, 1996-2002.	Avon Downs seasonal calving study
Elphinstone (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 413-415.	Post-weaning production feeding of steers 1994-95 (PDS)
Evans, T.R., Hacker, J.B. (1992). An evaluation of the production potential of six tropical grasses under grazing. 2. Assessment of quality using variable stocking rates. *Australian Journal of Experimental Agriculture.* 32: 29–37.	Responses of six tropical grasses to variable stocking rates 1971-74
Evans, T.R., Hacker, J.B. (1992). An evaluation of the production potential of six tropical grasses under grazing. 3. Responses to set stocking rates under continuous grazing. *Australian Journal of Experimental Agriculture.* 32: 693–699.	Responses of six tropical grasses to set stocking rates under continuous grazing
Filet *et al*. (1993). Improving liveweight gain using the heavy-duty plough on pastures infested with brigalow suckers. Proc. XVII Int. Grassl. Cong. 1993, pp 2022-2023.	Improving liveweight gain using the heavy-duty plough on pastures infested with brigalow suckers 1989-92
Fordyce *et al*. (1993b). Effect of surgical spaying of heifers on growth. Swans Lagoon Annual Report 1991 pp 16-17, 1992 pp 29-31, 1993 pp 25-26.	Effect of surgical spaying of heifers on growth 1990-92
Fossett & Venamore (1993). Evaluation of animal productivity and pasture yield after treatment of brigalow regrowth with Graslan. Proc. XVII Int. Grassl. Cong.1993, pp 2233-2234.	Evaluation of animal productivity and pasture yield after treatment of brigalow regrowth with Graslan 1989-92
Foster and Blight (1987). Daily liveweight change in winter, spring and autumn in unsupplemented and supplemented cattle grazing speargrass. Journal of Agriculture Animal Science. 44:59-68	Daily liveweight change in winter, spring and autumn in unsupplemented and supplemented cattle grazing speargrass 1977-1979
Gardener, C.J., McCaskill, M.R. & McIvor, J.G. (1993). Herbage and animal production from native pastures and pastures oversown with *Stylosanthes hamata*. 1. Fertiliser and stocking rate effects. *Australian Journal of Experimental Agriculture* 33: 561–570.	Liveweight gains from native pastures and pastures oversown with Verano stylo 1973-85
Gulbransen, B., Standfast, N.F. & Kempton, T.J. (1990). Supplementation of grazing steers with copra meal. *Proc. Aust. Soc. Anim. Prod*. 18: 236-239.	Supplementation of steers with copra meal
Hendricksen, R.E. & Punter, L.D. (1988). Seasonal growth rate of steers in relation to the stylo percentage of their diet. *Proc. Aust. Soc. Anim. Prod.* 17: 417.	Seasonal growth rate of steers in relation to the quantity of stylo in their diet 1985-87
Hendricksen, R.E., Ternouth, J.H. & Punter, L.D. (1994). Seasonal nutrient intake and phosphorus kinetics of grazing steers in northern Australia. *Australian Journal of Agricultural Research.* 45: 1817–1829.	Effect of superphosphate fertiliser and phosphorus supplement on liveweight change of Brahman cross steers grazing native grass and native grass-Seca stylo pastures 1989-90
Hill (1996) Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 322-327.	Liveweight gains of supplemented steers 1994-96 (PDS)
Hill (1998) Producer Demonstration Sites Project Report 1996-98, pp 1-7.	Production feeding of steers and heifers 1996-1997 (PDS) (2)
Hill F. (1998), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	Growing out steers prior to shipping to the Philippines 1997-98

Holroyd, R.G., Dunster, P.J. & O'Rourke, P.K. (1988). Effect of cattle tick (*Boophilus microplus*) infestation on performance of *Bos indicus* cross cows and their progeny. *Australian Journal of Experimental Agriculture.* 28: 1–9.	Effect of cattle tick infestation on performance of *Bos indicus* cross cows and their progeny 1977-80
Houston, E.M., Schlink, A.C. & Hunter, R.A. (1992). The effect of trenbolone acetate on the rates of liveweight loss and subsequent gain by steers grazing native pasture in northern Australia. *Proc. Aust. Soc. Anim. Prod.* 19: 403-405.	The effect of trenbolone acetate on the rates of liveweight loss and subsequent gain by steers grazing native pasture in northern Australia.
Hunt, L., Petty, S., Cowley, R., Fisher, A., White, A., MacDonald, N., Pryor, M., Ash, A., McCosker, K., McIvor, J., & MacLeod, N. (2013). Sustainable development of Victoria River District (VRD) grazing lands. Final Report. Meat & Livestock Australia: North Sydney.	Sustainable development of Victoria River District (VRD) grazing lands - Mount Sanford Project
Hunter, R. A., Magner, T. & Allingham P. G. (2000). Sustained growth promotion, carcass characteristics, and meat quality of steers treated with oestradiol-17b. *Australian Journal of Agricultural Research.* 51: 133–138.	Effect of repeated treatment with hormone growth promotants on slaughter weight and yield of Belmont Red cross steers
Jones, R. J. (1997). Steer gains, pasture yield and pasture composition on native pasture and on native pasture oversown with Indian couch (*Bothriochloa pertusa*) at three stocking rates. *Australian Journal of Experimental Agriculture.* 37: 755–765. Jones, R.J. & Coates, D.B. (1992). The effect of age on steer liveweight gain on continuously stocked tropical pastures. *Proc. Aust. Soc. Anim. Prod*. 19: 39-42.	The effect of age on steer liveweight gain on continuously stocked tropical pastures 1990-91
Jones, R.J. (1989). Nitrogen-fertilised pastures of Narok setaria and Samford rhodes grass give similar beef production in S.E. Queensland. *Tropical Grasslands.* 23: 65-74.	Beef production from nitrogen-fertilised pastures of Narok setaria and Samford Rhodes grass 1970-74
Jones, R. & Bunch, G. (1995). Long-term records of legume persistence and animal production from pastures based on Safari Kenya clover and leucaena in subtropical coastal Queensland. *Tropical Grasslands.* 29: 74-80.	Long-term records of legume persistence and animal production from pastures based on Safari Kenya clover and leucaena in subtropical coastal Queensland
Kernot (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 190-194.	Liveweight performance of steers and cows with access to ponded pasture 1992-93 (PDS)
Kernot (1998). Producer Demonstration Sites Project Report 1996-98, pp 18-22.	Liveweight gains of Charbay steers and heifers grazing leucaena 1996 (PDS)
Kerridge, P.C., Gilbert, M.A. & Coates, D.B. (1990). The status and management of soil phosphorus in relation to beef production *Tropical Grasslands.* 24: 221-230.	The relationship between rate of liveweight gain and soil P(B) for the wet season
Kidd, J.F. & McLennan, S.R. (1998). Relationship between liveweight change of cattle in the dry season in northern Australia and growth rate in the following wet season. *Proc. Aust. Soc. Anim. Prod.* 22: 363.	Relationship between liveweight change of cattle in the dry season in northern Australia and growth rate in the following wet season
Laing (1996a). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 22-25.	The effect of phosphorus supplementation on liveweight performance of Brahman steers grazing native and stylo pastures 1990-94 (PDS)
Laing (1996d). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 369-372.	Liveweight performance of steers grazing irrigated pastures 1992-96 (PDS)
Lambert (1996). Producer Demonstration sites Annual Report 1995-96, pp. 126-128.	Liveweight performance of steers grazing leucaena plus buffel grass in brigalow area III 1991-98 (PDS)
Lindsay, J.A., Kendall, I.E., Gelling, B.A. & Mayer, R.J. (1990). Effects of monensin sodium and avoparcin on the liveweight gain of steers during the north Queensland wet season. *Proc. Aust. Anim. Prod.* 18: 513.	Effects of monensin sodium and avoparcin on the liveweight gain of steers during the wet season 1988-89
Lindsay, J.A., Kidd, J.F., Kendall, I.E., Gelling, B.A. & Mayer, R.J. (1990). A comparison of three rumen modifiers added to a cottonseed meal supplement and fed to growing beef cattle. *Proc. Aust. Soc. Anim. Prod.* 18: 514.	A comparison of three rumen modifiers added to a cottonseed meal supplement and fed to growing young cattle
Lindsay *et al*. (1995). Swans Lagoon Annual Report 1995, pp 100-104.	Beef production from first-calf cows 1994-95
McCaskill, M.R. & McIvor, J.G. (1993). Herbage and animal production from native pastures and pastures oversown with *Stylosanthes hamata*. 2. Modelling studies. *Australian Journal of Experimental Agriculture.* 33: 571–579.	Liveweight gains from native pastures and pastures oversown with Verano stylo 1973-85 and Animal production from stylo pastures at four sites in northern Australia
McCosker (1987). Agronomic and grazing evaluation of three lines of *Centrosema pascuorum* under seasonally flooded	Grazing evaluation of three lines of *Centrosema pascuorum* under seasonally flooded conditions 1984

conditions in the Northern Territory. *Tropical Grasslands.* 21: 81-91.	
McGowan, M., McCosker, K., Fordyce, G., Smith, D., O'Rourke, P., Perkins, N., Barnes, T., Marquart, L., Morton, J., Newsome, T., Menzies, D., Burns, B. & Jephcott, S. (2014). Northern Australian beef fertility project: CashCow. Meat and Livestock Australia Final Report.	CashCow Project
McLennan & Hobbs (1987). Swans Lagoon Annual Report 1987, pp 39-45.	Liveweight performance on native pastures and fertilised and unfertilised Townsville stylo pastures 1971-86
McLennan *et al*. (1991). Swans Lagoon Annual Report 1987, pp 46-54, 1988, pp 59-67, 1989, pp 72-74, 1991, pp 74-77.	Liveweight performance of *Bos indicus* cross steers grazing native pastures and perennial stylo pastures 1986-91
Middleton (1996c). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 44-47.	Liveweight performance of steers grazing seca stylo 1991-95 (PDS)
Middleton *et al*. (1993). Proc. XVII Int. Grassl. Cong. 1993, pp 1994-1996. Middleton (1996a). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 16-21.	Liveweight change of Brahman cross steers grazing native pasture and native pasture with Seca stylo 1984-91 (PDS)
Middleton *et al*. (1993). Proc. XVII Int. Grassl. Cong. 1993, pp 1994-1996. Middleton (1996b). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 39-42.	Liveweight change of Brahman cross steers grazing native pasture and native pasture with Seca stylo 1984-91 (PDS)
Miller & Hendricksen (1993). Proc. XVII Int. Grassl. Cong. 1993, pp 1984-85.	Steer growth in response to legume and phosphorus supply 1988-90
Mullins (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 186-189.	Liveweight performance of steers grazing forage sorghum 1990-94 (PDS)
Murphy (1998). Producer Demonstration Sites Project Report 1996-98, pp 74-79.	Liveweight gain of Brahman heifers and steers grazing regenerated country 1995-99 (PDS)
Northern Territory Department of Business, Industry and Resource Development, Primary Industry Group, Technical Annual Report 2001/2002. Page 68-72.	Breeder herd efficiency: Austral Downs
Northern Territory Government (2015). Primary Industries Annual Research Achievements Report 2013-14. Department of Primary Industry and Fisheries. Technical Bulletin No. 353.	Making production and conservation gains through adaptive grazing: Beetaloo Pilot Project
Northern Territory Government (2015). Primary Industries Annual Research Achievements Report 2013-14. Department of Primary Industry and Fisheries. Technical Bulletin No. 353.	Improving breeder herd efficiency in the arid region with performance recording and objective selection (OMP Quality Graze and Old Man Plains Research Station)
Northern Territory Government (2015). Primary Industries Annual Research Achievements Report 2013-14. Department of Primary Industry and Fisheries. Technical Bulletin No. 353.	Selected Brahmans - Improvement in the fertility of the Brahman breed through the use of Breedplan EBVs and selection
NTDPIF (unpublished)	AZRI sentinel herd data
NTDPIF (unpublished)	VRRS (Kidman Springs) progeny data
NTDPIF (unpublished)	Helen Springs Producer Demonstration Site- Bull Breeding (recently commenced)
O'Reagain, P.O., Bushell, J., Holloway, C. & Reid, A. (2009). Managing for rainfall variability: effect of grazing strategy on cattle production in a dry tropical savanna. *Animal Production Science.* 49: 85–99.	Wambiana grazing trial
O'Rourke, P.K., Doogan, V.J., Robertson, D.J. & Cooke, D. (1991). Prediction of conception rate in extensive beef herds in north-western Australia. 2. Continuous mating and minimal management. *Australian Journal of Experimental Agriculture.* 31: 9–14.	Pregnancy rate of a herd in north-western Australia under continuous mating and minimal management 1981-85
Partridge & Wright (1992). Effects of oversowing with Wynn cassia and superphosphate application on steer liveweight gains on native pasture. *Tropical Grasslands.* 26: 263-269.	Effects of oversowing with Wynn cassia and superphosphate application on steer liveweight gains on native pasture 1984-90
Paton, C.J., Myles, D.J. & Quirk, M.F. (1992). Cattle production on black speargrass pastures improved with either Leucaena or shrubby stylo. *Proc. Aust. Soc. Anim. Prod.* 19: 35-38.	Liveweight performance of steers grazing speargrass pastures improved with either leucaena or shrubby stylo 1983-88
Petherick, J.C., Fry, P.D., Mayer, R.J. & Dixon, R.M. (1998). Effects of lick block siting on supplement intake and behaviour	Effects of lick-block siting on supplement intake and behaviour of cattle

of cattle. *Proc. Aust. Soc. Anim. Prod.* 22:291.	
Pratchett & Petty (1993). Increasing cool season production from irrigated leucaena pastures. Proc. XVII Int. Grassl. Cong. pg 1983.	Increasing cool season production from irrigated leucaena pastures
Pratchett & Triglone (1989). Liveweight gain, carcase weight and fat depth of cattle grazing irrigated leucaena and pangola pastures *West. Aust. J. Agric*. 30: 62-66.	Liveweight gain, carcase weight and fat depth of cattle grazing irrigated leucaena and pangola pastures 1984-87
Quigley, S., Poppi, D. & Schatz, T. (2014). Validation and demonstration of a diagnostic tool for phosphorus status of beef cattle. Final Report. Meat & Livestock Australia.	Phosphorus Trial
Quirk, M.F., Bushell, J.J., Jones, R.J., Megarrity, R.G. & Butler, K.L. (1988). Live-weight gains on leucaena and native grass pastures after dosing cattle with rumen bacteria capable of degrading DHP, a ruminal metabolite from leucaena. *The Journal of Agricultural Science*. 111: 165-170.	Liveweight performance on leucaena and native grass pastures 1984-85
Quirk, M.F., Paton, C.J. & Bushell, J.J. (1990). Increasing the amount of leucaena on offer gives faster growth rates of grazing cattle in South East Queensland. *Australian Journal of Experimental Agriculture.* 30: 51–54.	Improving liveweight gains of grazing cattle with leucaena 1984-85
Quirk, M (1998), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	Annual liveweight gains of zebu cross steers grazing the major land systems of the inland Burnett 1985-95
Rakuita, B.C., Mullaly, J.D, Robbins, G.B., & Paton, C.J. (1992). Finishing cattle on Leucaena. *Proc. Aust. Soc. Anim. Prod*. 19:51.	Finishing cattle on Leucaena 1986-91
Ridley, P.E.R. & Schatz, T.J. (2007). Meeting post weaning market specifications for the live cattle export trade to South East Asia. MLA final report NAP 3.111. Meat and Livestock Australia: North Sydney.	Live export trial
Robbins & Bushell (1988). Brian Pastures Annual Report 1987-88, p12.	Comparative productivity of six grasses 1982-87
Robertson R. (1999), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	Comparison of liveweight gains of cattle supplemented with cottonseed meal, copra meal or palm kernel extract
Robertson R. (1999), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	Liveweight performance of steers grazing native pastures 1985-99
Robertson R. (1999), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	Using leucaena to reduce age of turnoff from native pastures 1985-98
Robertson R. (1999), pers. comm. In: Hasker, P.J.S. (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland: Brisbane)	The effect of technical grade phosphoric acid on growth rate and intake of molasses-based supplements 1996
Salmond (1995). Producer Demonstration Sites Project Report 1994-95, pp 152-155.	Liveweight performance of steers grazing a winter forage crop of vetch plus oats (PDS)
Savage, D. (2004). Nutritional influences on reproductive performance of beef cattle in the Barkly Tableland. (PhD Thesis, University of New England). Savage, D. (2005). Nutritional influences on beef breeding performance, MLA Final Report.	Nutritional influences on Barkly beef breeding performance
Schatz, T.J., Ridley, P.E.R., Fontaine, D.J.M.L. & Hearnden, M.N. (2007). Effects of genotype, sex and stocking rate on postweaning efficiency and value-adding potential at turnoff of weaners grazing improved pasture in the Douglas Daly region of the Northern Territory. *Australian Journal of Experimental Agriculture.* 47: 1272–1276.	Douglas Daly Research Farm Grazing Trial
Schatz, T.J., Thomas, S. & Geesink, G. (2014). Comparison of the growth and meat tenderness of Brahman and F1 Senepol Brahman steers. *Animal Production Science*. 54: 1867–1870.	DDRF Breed comparison
Schatz, T.J. (2010). Understanding and improving heifer	Heifer fertility project

fertility in the Northern Territory. Final Report Project NBP.339. Meat and Livestock Australia, North Sydney.	
Schatz, T.J. (2013). Central Australian heifer research and demonstration project: Tieyon Station. A summary of heifer research at Tieyon from 2005 to 2012. Northern Territory Government, Australia. Technical Bulletin No. 344.	Central Australian heifer research and demonstration project: Tieyon Station
Schatz, T.J. (unpublished)	Douglas Daly data 2
Scott, K., Krafft, P. & Cowley, R. (2009). Newcastle Waters cell grazing trial: an evaluation of cell and continuous grazing in the north-eastern Barkly region, Department of Primary Industry & Fisheries Draft Final Report.	Newcastle Waters cell grazing trial
Shaw (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 26-28.	Liveweight performance of Brahman cross steers grazing native pasture and stylo pastures (PDS)
Silcock (1996). DAQ.090 Final Report, December 1996.	Liveweight performance of *Bos indicus* cross steers grazing Aristida-Bothriochloa pasture 1994-96
Silcock, R.G., Filet, P.G., Hall, T.J., Thomas, E.C., Day, K.A., Kelly, A.M., Knights, P.T., Robertson, B.A. & Osten, D. (1996). Enhancing pasture stability and profitability for producers in Aristida/Bothriochloa woodlands. (DAQ.090).' Final Report (1992–1996) to Meat Research Corporation.	Aristida-Bothriochloa project
Smith (1996c) Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 56-65.	Effect of wet season supplementation with sodium and sulphur on liveweight of lactating Droughtmaster cows and their calves 1986-87 (PDS)
Smith (1996d). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 5-8.	Liveweight performance of steers grazing stylo pastures 1984-91 (PDS)
Streeter, S., Perkins, N., Cowley, T. & MacDonald, N. (2013). Causal factors affecting liveweight gain in north Australian beef herds. Meat & Livestock Final Report NBP. 0390.	NT Liveweight gain project
Sullivan, M. T. (1996b). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 336-339.	Production feeding of Brahman cross steers 1992-93 (PDS)
Sullivan, M. T. (1996c). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 127-139.	Millungera breeding management demonstration 1989-93 (PDS)
Teitzel, J.K. & Wilson, R.J. (1991). Productive and stable pasture systems for cattle fattening in the humid tropics. 2. Field testing on a naturally infertile site. *Agricultural Systems*. 36: 267-277.	Six pasture/cattle fattening systems on a naturally infertile soil
Teitzel, J.K., Wilson, R.J. & Mellor, W. (1991). Productive and stable pasture systems for cattle fattening in the humid tropics. 1. Field testing on a naturally fertile site. *Agricultural Systems*. 36: 251-265.	Five pasture/cattle fattening systems on a naturally fertile soil
Thompson, R.J. (1990). Growth responses of Brahman cross steers administered with monensin alone, or in combination with oestradiol 17B. *Proc. Aust. Soc. Anim. Prod*. 18: 561.	Growth response of Brahman cross steers to monensin alone, or in combination with Compudose 200
Tudor, G.D., James, T. & Hunter, R.A. (1992). Seasonal growth and carcass characteristics of grazing steers implanted with trenbolone acetate and oestradiol. *Australian Journal of Experimental Agriculture.* 32: 683–687.	Seasonal growth and carcase characteristics of grazing steers implanted with trenbolone acetate and oestradiol 1989-90
Tyler (1996c). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 13-15.	Liveweight performance of weaners and yearlings grazing grass-legume pastures 1983-95
Tyler (1996c). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 9-12.	Liveweight performance of steers on legume pastures 1983-94 (PDS)
Wesley-Smith (1972). Liveweight gains of Shorthorn steers on native and improved pastures at Adelaide River, NT. *Australian Journal of Experimental Agriculture and Animal Husbandry* 12: 566-572.	Liveweight gain of Shorthorn steers at Adelaide River, NT.
Wilson, R.J. & O'Rourke, P.K. (1990). Time to turn off steers in the high rainfall tropics. *Proc. Aust. Soc. Anim. Prod.* 18: 567.	Time to turn off steers in the high-rainfall tropics 1977-86
Winks, R., Burns, M.A., Berrie, D.A., East, I.J., Kelly, J.G. & Bremner, K.C. (1987). Effect of repeated anthelmintic treatment on weight gain in Hereford and Brahman crossbred cattle in south-eastern Queensland. *Australian Journal of Experimental Agriculture.* 27: 189–193.	Effect of repeated anthelmintic treatment on weight gain in Hereford and Brahman cross steers 1979-81
Winter, W.H. (1987). Using fire and supplements to improve cattle production from monsoon tallgrass pastures. *Tropical Grasslands.* 21: 71-81.	Using fire and supplements to improve cattle production from monsoonal tallgrass pastures 1980-83

Wesley-Smith (1972). Liveweight gains of Shorthorn steers on native and improved pastures at Adelaide River, NT. *Australian Journal of Experimental Agriculture and Animal Husbandry* 12: 566-572.	Liveweight gain of Shorthorn steers at Adelaide River, NT.
Wilson, R.J. & O'Rourke, P.K. (1990). Time to turn off steers in the high rainfall tropics. *Proc. Aust. Soc. Anim. Prod.* 18: 567.	Time to turn off steers in the high-rainfall tropics 1977-86
Winks, R., Burns, M.A., Berrie, D.A., East, I.J., Kelly, J.G. & Bremner, K.C. (1987). Effect of repeated anthelmintic treatment on weight gain in Hereford and Brahman crossbred cattle in south-eastern Queensland. *Australian Journal of Experimental Agriculture.* 27: 189–193.	Effect of repeated anthelmintic treatment on weight gain in Hereford and Brahman cross steers 1979-81
Winter, W.H. (1987). Using fire and supplements to improve cattle production from monsoon tallgrass pastures. *Tropical Grasslands.* 21: 71-81.	Using fire and supplements to improve cattle production from monsoonal tallgrass pastures 1980-83
Winter, W.H. (1988). Supplementation of steers grazing *Stylosanthes hamata* pastures at Katherine, Northern Territory. *Australian Journal of Experimental Agriculture.* 28: 669–682.	Supplementation of steers grazing stylo pastures
Winter WH, Coates DB, Hendricksen RE, Kerridge GE PC, Mclean RW and Miller CP (1990) The response of cattle to fertiliser and supplementary phosphorus. *Tropical Grasslands* 24: 170-184	Animal production from stylo pastures at 4 sites in northern Australia
Winter, W.H., Mott, J.J. & McLean, R.W. (1989). Evaluation of management options for increasing the productivity of tropical savanna pastures. 2. Legume species. *Australian Journal of Experimental Agriculture.* 29: 623–630.	Liveweight gains of Brahman cross steers grazing unfertilised and fertilised stylo-sown native pastures at varying stocking rates 1979-80
Winter, W.H., Mott, J.J., McLean, R.W. & Ratcliff, D. (1989). Evaluation of management options for increasing the productivity of tropical savanna pastures. 1. Fertiliser. *Australian Journal of Experimental Agriculture.* 29: 613–622.	Effect of fertiliser on liveweight of steers grazing stylo pastures
Wood (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 157-159.	Liveweight performance of cows and calves supplemented with phosphorus in drinking water 1988 (PDS)
Wright (1996). Producer Demonstration Sites Final Report 1996, DAQ.M001, Part 4, pp 242-245.	Effect of phosphorus and sulphur supplementation on the liveweight performance of steers grazing speargrass legume pastures (PDS)
Yang, G.R, Robbins, G.B. & Paton, C.J. (1992). Feeding a protein and energy supplement to boost the growth of cattle grazing native pastures improved with legumes. *Proc. Aust. Soc. Anim. Prod.* 19: 50.	Feeding a protein and energy supplement to boost the growth of cattle grazing native pastures improved with legumes

Pasture quality references and project name

Reference	Project Name
Bowen, M., Chudleigh, F., Buck, S. & Hopkins, K. (2015). High-output forage systems for meeting beef markets - Phase 2 Final Report. Meat and Livestock Australia, North Sydney.	2011-2014 (Cattle Downs), 2012 (Gordon Downs), 2012 (Rosewood), 2013 (Cariage) - new paddock, 2012 (Coolibah), 2012 (Gordon Downs), 2012 (Rosewood), 2012 (Gordon Downs), 2013 (Wilga Vale)
Bray, S., Walsh, D., Rolfe, J., Broad, K., Phelps, D., Cowley, R., Daniels, B., Emery, T., English, B., Ffoulkes, D., Gowen, R., Gunther, R., Hegarty, E., Houston, I., McGrath, T., Pahl, L., Shotton, P., Sneath, R. & Whish, G. (2015). Northern grazing carbon farming – integrating production and greenhouse gas outcomes 1&2. Climate Clever Beef Final Report. Department of Agriculture and Fisheries, Rockhampton.	Dunblane, Glenlinden, Springtime, Julia Creek, Ninderra - Lower Bullock, Ninderra – Brigalow, Oaklands
Coates, D.B. & Dixon, R.M. (2007). Faecal near infrared reflectance spectroscopy (F.NIRS) measurements of non-grass proportions in the diet of cattle grazing tropical rangelands. *The Rangeland Journal.* 29: 51-63.	Forest Homes, Brian Pastures, Swans Lagoon, Frankfield, Glentulloch, Rosebank, Longreach Pastoral, Toorak, Morungle Station, Croxdale, Ryandale Station, Oakley Station
Hall, T.J., McIvor, J., Jones, P., MacLeod, N., McDonald, C., Reid, D., Smith, D. & Delaney, K. (2011). Volume 1 - Investigating intensive grazing systems in northern Australia. MLA Final Report. Meat and Livestock Australia, North Sydney.	Banyula, Berrigurra, Frankfield, Melrose, Rocky Springs, Salisbury Plains, Somerville, Sunnyholt, Ticehurst
Hegarty, E., Broad, K., English, B., Gunther, R. & Rolfe, J. (2015). Using Walk Over Weighing and remote camera monitoring to identify key management triggers and reduce costs. Final report. Meat and Livestock Australia, North Sydney.	Walk Over Weighing (WOW)
Hunt, L., Petty, S., Cowley, R., Fisher, A., White, A., MacDonald, N., Pryor, M., Ash, A., McCosker, K., McIvor, J. & MacLeod, N. (2013). Sustainable development of Victoria River District (VRD) grazing lands. Final Report. Meat and Livestock Australia, North Sydney.	Sustainable development of Victoria River District (VRD) grazing lands.
McGowan, M., McCosker, K., Fordyce, G., Smith, D., O'Rourke, P., Perkins, N., Barnes, T., Marquart, L., Morton, J., Newsome, T., Menzies, D., Burns, B. & Jephcott, S. (2014). Northern Australian beef fertility project: CashCow. Final Report. Meat and Livestock Australia, North Sydney.	CashCow project
NT DPI&F (unpublished data)	Mt Sanford Station
NT DPI&F (unpublished data)	Lake Nash Breeder Herd Efficiency
NT DPI&F (unpublished data)	Barkly Landcare pasture quality collaborative project – Alroy Downs
NT DPI&F (unpublished data)	Humbert River Station, Arid Zone Research Institute sentinel data, Berrimah Research Station, Victoria River Research Station
O'Reagain P.O., Bushell J., Holloway C. & Reid A. (2009). Managing for rainfall variability: effect of grazing strategy on cattle production in a dry tropical savanna. *Animal Production Science.* 49: 85–99.	Wambiana
Ramirez, Gonzalez, Charmley & O'Neill (unpublished data)	Lansdowne
Savage, D. (2004). Nutritional influences on reproductive performance of beef cattle in the Barkly Tableland. (PhD Thesis, University of New England). Savage, D. (2005). Nutritional influences on beef breeding performance, MLA final report.	Alexandria burning trial
Schatz, T.J., Ridley, P.E.R., Fontaine, D.J.M.L. & Hearnden, M.N. (2007). Effects of genotype, sex and stocking rate on postweaning efficiency and value-adding potential at turnoff of weaners grazing improved pasture in the Douglas Daly region of the Northern Territory. *Australian Journal of Experimental Agriculture.* 47: 1272–1276.	Douglas Daly Research Farm grazing trial
Streeter, S., Perkins, N., Cowley, T. & MacDonald, N. (2013). Causal factors affecting liveweight gain in north Australian beef herds. Final Report M.NBP. 0390. Meat and Livestock Australia, North Sydney.	Victoria River District, Barkly Tableland, Floodplain North, Katherine region, Floodplain West, East Arnhem

Appendix 3: Summary regional statistics

Region	Area (ha)	% of state area	Average rainfall (mm)	Soil organic carbon (t/ha)	Total Soil Phosphorus (%)	Beef cattle number	% of state herd	Pasture productivity (kg/ha/yr)
Queensland								
R311A	12978694	8	1362	43.5	0.018	125000	1	1988
R311B	11427904	7	767	26.9	0.021	557293	5	2119
R312	54420018	31	294	17.6	0.031	1228150	11	700
R313B	13173793	8	829	35.4	0.026	666914	6	2412
R313C	6837348	4	628	35.3	0.033	599212	5	2608
R313E	10850660	6	474	22.8	0.035	842899	7	1625
R314	16517993	10	459	26.1	0.029	935548	8	1728
R321	2582218	1	659	51.4	0.057	445360	4	3045
R322	26124403	15	562	39.8	0.036	3482678	31	2333
R331	12708119	7	802	55.6	0.042	1898707	17	3289
R332A	1457560	1	2359	76.6	0.046	119215	1	3246
R332B	3916909	2	905	45.7	0.030	454010	4	3424
Northern Territory								
R711	56956618	42	300	16.2	0.019	280745	16	474
R712	30329457	22	429	17.7	0.019	609105	34	854
R713	23397496	17	837	30.8	0.020	718671	40	1948
R714	24135536	18	1137	35.0	0.018	186881	10	1995

Number of liveweight data values for each CSIRO region

Row Labels	Bulls	Females	Steers
R311A	21	65	50
R311B	21	53	32
R312	21	55	42
R313B	126	452	316
R313C	58	124	712
R313E	29	303	85
R314	23	116	112
R321	31	65	35
R322	94	313	505
R331	92	753	322
R332A	23	53	38
R332B	21	243	159
R711	96	761	158
R712	41	124	70
R713	39	342	173
R714	29	54	37
Grand Total	765	3876	2846

Appendix 4: Proposed LW, LWG, CP and DMD reference tables

Queensland LW

State	Region	Season	Bulls <1	Bulls >1	Cows <1	Cows 1-2	Cows 2-3	Cows >3	Steer s <1	Steer s 1-2	Steer s 2-3	Steer s >3
Qld	Low	Summer	119	591	140	205	310	405	133	218	315	445
		Autumn	175	610	163	232	351	427	146	242	320	471
		Winter	192	615	162	255	364	420	157	261	342	484
		Spring	190	617	174	265	371	415	170	272	392	531
Qld	Moderate/ Low	Summer	120	669	112	250	390	448	115	273	433	556
		Autumn	125	685	140	277	407	455	141	296	445	593
		Winter	180	692	183	316	438	468	189	354	500	553
		Spring	236	674	178	310	428	466	193	370	519	565
Qld	Moderate /High	Summer	113	669	113	283	361	477	120	273	545	553
		Autumn	172	685	172	309	376	471	238	329	573	620
		Winter	241	692	208	344	364	484	260	350	567	620
		Spring	230	674	217	344	357	467	242	370	550	620
Qld	High	Summer	153	703	118	277	397	483	111	304	521	547
		Autumn	168	718	191	319	440	506	188	326	520	582
		Winter	235	722	207	352	470	514	209	421	512	605
		Spring	260	705	215	302	416	519	234	455	551	660

Northern Territory LW

State	Region	Season	Bulls <1	Bulls >1	Cows <1	Cows 1-2	Cows 2-3	Cows >3	Steers <1	Steer s 1-2	Steers 2-3	Steers >3
NT	Alice Springs	Summer	110	703	112	256	368	465	108	280	421	543
		Autumn	170	721	169	306	392	464	176	339	470	580
		Winter	200	727	211	338	432	492	222	377	498	590
		Spring	220	706	208	323	415	467	223	371	493	585
NT	Barkly Region	Summer	110	650	108	262	346	430	111	236	n/a	n/a
		Autumn	170	670	170	266	363	444	169	282	n/a	n/a
		Winter	200	660	225	307	398	452	214	326	n/a	n/a
		Spring	220	620	227	319	398	452	216	334	n/a	n/a
NT	Northern NT	Summer	110	650	102	203	299	380	102	218	263	n/a
		Autumn	170	670	173	250	336	414	175	243	304	n/a
		Winter	200	660	202	272	365	390	208	260	337	n/a
		Spring	220	620	177	267	365	406	213	249	324	n/a

n/a No cattle in this age class in this region.

Queensland LWG

State	Region	Season	Bulls <1	Bulls >1	Cows <1	Cows 1-2	Cows 2-3	Cows >3	Steers <1	Steers 1-2	Steers 2-3	Steers >3
Qld	Low	Summer	0.62	0.21	0.25	0.32	0.47	0.31	0.14	0.40	0.26	0.43
		Autumn	0.40	0.13	0.12	0.27	0.30	0.08	0.13	0.24	0.15	0.21
		Winter	0.08	0.04	0.06	0.18	0.11	-0.07	0.13	0.16	0.40	0.33
		Spring	-0.02	0.02	0.24	0.30	0.23	-0.05	0.34	0.30	0.57	0.52
Qld	Moderate/ Low	Summer	0.05	0.19	0.31	0.54	0.53	0.15	0.28	0.57	0.42	0.40
		Autumn	0.33	0.13	0.39	0.36	0.26	0.11	0.40	0.44	0.37	-0.01
		Winter	0.61	-0.06	0.21	0.18	0.12	0.06	0.29	0.41	0.41	-0.15
		Spring	0.62	-0.19	0.37	0.41	0.06	-0.02	0.47	0.44	0.30	0.13
Qld	Moderate /High	Summer	0.65	0.19	0.65	0.51	0.18	0.63	1.30	0.48	1.12	0.38
		Autumn	0.70	0.13	0.52	0.34	0.02	0.04	0.77	0.42	0.12	0.74
		Winter	0.32	-0.06	0.25	0.19	-0.10	-0.02	0.02	0.23	-0.13	0
		Spring	-0.12	-0.19	0.41	0.09	0.41	-0.19	0.07	1.07	-0.08	0
Qld	High	Summer	0.16	0.16	0.80	0.57	0.76	0.49	0.84	0.51	0.36	0.17
		Autumn	0.45	0.10	0.49	0.41	0.40	0.17	0.54	0.64	-0.05	0.32
		Winter	0.51	-0.07	0.13	-0.09	-0.13	0.07	0.25	0.71	0.17	0.43
		Spring	0.27	-0.19	0.38	0.25	0.07	0.05	0.52	0.55	0.19	0.60

Northern Territory LWG

State	Region	Season	Bulls <1	Bulls >1	Cows <1	Cows 1-2	Cows 2-3	Cows >3	Steers <1	Steers 1-2	Steers 2-3	Steers >3
NT	Alice Springs	Summer	0.66	0.20	0.62	0.54	0.38	0.27	0.75	0.64	0.55	0.48
		Autumn	0.49	0.13	0.54	0.45	0.35	0.15	0.63	0.54	0.42	0.26
		Winter	0.27	-0.08	0.22	0.09	0.12	0.02	0.25	0.18	0.12	0.03
		Spring	0.22	-0.23	0.25	0.17	0.18	-0.28	0.32	0.24	0.25	-0.05
NT	Barkly Region	Summer	0.66	0.22	0.68	0.22	0.24	0.25	0.64	0.37	n/a	n/a
		Autumn	0.49	0.05	0.64	0.25	0.29	0.12	0.57	0.49	n/a	n/a
		Winter	0.27	-0.27	0.31	0.29	0.19	0.04	0.26	0.28	n/a	n/a
		Spring	0.22	-0.44	0.20	0.21	0.18	0.01	0.12	0.09	n/a	n/a
NT	Northern NT	Summer	0.66	0.22	0.79	0.40	0.38	0.27	0.80	0.16	0.30	n/a
		Autumn	0.49	0.05	0.55	0.38	0.36	0.06	0.58	0.23	0.40	n/a
		Winter	0.27	-0.27	0.02	0.09	0.16	-0.04	0.21	0.03	0.11	n/a
		Spring	0.22	-0.44	0.00	0.15	0.08	0.17	0.06	0.02	-0.14	n/a

n/a No cattle in this age class in this region.

Queensland and Northern Territory CP %

State/Territory	Season	Current NIR value	Proposed NIR value
QLD	Spring	5	7.2
	Summer	15	9.9
	Autumn	11	7.8
	Winter	6	5.9
Northern Territory	Spring	4	5.8
	Summer	12	9.2
	Autumn	7	7.5
	Winter	5	5.3

Queensland and Northern Territory DMD %

State/Territory	Season	Current NIR value	Proposed NIR value
QLD	Spring	55	53
	Summer	65	57
	Autumn	58	55
	Winter	52	51
Northern Territory	Spring	40	55
	Summer	65	61
	Autumn	55	57
	Winter	45	54

Appendix 5: Proportion of regional herd number in each livestock class

Proportion of regional herd number in each livestock class and proportion of Cows >2 (Cows 2-3 plus >3) lactating for the full period for each region in Queensland and NT.

State	Region	Bulls <1	Bulls >1	Cows <1	Cows 1-2	Cows 2-3	Cows >3	Steers <1	Steers 1-2	Steers 2-3	Steers >3	Proportion lactating
Qld	Low	0.003	0.018	0.124	0.106	0.086	0.353	0.120	0.114	0.060	0.016	0.561
Qld	Moderate /Low	0.003	0.016	0.134	0.089	0.080	0.370	0.131	0.096	0.051	0.030	0.609
Qld	Moderate /High	0.002	0.013	0.150	0.121	0.073	0.219	0.148	0.147	0.108	0.019	1.000[a]
Qld	High	0.002	0.013	0.150	0.127	0.091	0.310	0.148	0.106	0.037	0.016	0.748
NT	Alice Springs	0.003	0.020	0.112	0.109	0.097	0.343	0.109	0.109	0.080	0.018	0.511
NT	Barkly	0.004	0.026	0.090	0.131	0.109	0.541	0.085	0.014	0.000	0.000	0.534
NT	Northern NT	0.003	0.019	0.128	0.119	0.094	0.424	0.125	0.076	0.012	0.000	0.494

[a] This value is high due to yearling mating in the region. Value is 0.726 for Cows 1-2, 2-3 and >3.