Feeding forages in the Fitzroy

A guide to profitable beef production in the Fitzroy River catchment

MEAT & LIVESTOCK AUSTRALIA

Queensland Government

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This publication has been compiled by Maree Bowen, Stuart Buck and Fred Chudleigh, Department of Agriculture and Fisheries.

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Terms and abbreviations

AE	adult equivalent; a 450 kg, non-lactating animal, calculated as liveweight to the power 0.75
BOM	Bureau of Meteorology
C	carbon
C_3 species	species other than tropical grasses, including oats, legumes and browse from trees and shrubs
Cattle price margin	sale price of cattle less the purchase price ($/kg liveweight)
Cl	chloride
CP	crude protein; (N × 6.25)
CRC	Co-operative Research Centre
d	day
DAF	Department of Agriculture and Fisheries
DM	dry matter
DMD	dry matter digestibility; the proportion of feed an animal digests in the stomachs
EU	European Union; used to refer to one of the market options for Australian beef producers
Forage costs	the costs of forage establishment and maintenance. For butterfly pea–grass and leucaena–grass pastures that have a productive life of more than one year, the establishment costs were amortised (added as an average annual cost) in the calculation of the gross margin
Gross margin: contract rates	the gross income received from the sale of cattle less the variable costs incurred, including labour costs of machinery operations but not of handling livestock; calculated using a pseudo contract rate to cost actual machinery operations used by the co-operator
Gross margin: owner rates	the gross income received from the sale of cattle less the variable costs incurred, including labour costs of machinery operations but not of handling livestock; calculated as if plant and machinery is owned by the business with overhead costs excluded from the gross margin
ha	hectare
hd	head
HGP	hormonal growth promotant
LW	liveweight
LWG	liveweight gain
ME	metabolisable energy; the energy left after losses in faeces, urine and methane gas are subtracted
MJ	megajoule; a unit of energy
MLA	Meat and Livestock Australia
MSA	Meat Standards Australia
mths	months
N	nitrogen

NIRS	near infrared reflectance spectroscopy
P	phosphorus
PAWC	plant available water capacity; the quantity of water that the plant species can extract from the soil
PCAS	Pasturefed Cattle Assurance System
Pdk	paddock
SR	stocking rate
yrs	years

1 Introduction

Beef production is the major land use in the Fitzroy River catchment, occurring on around 12.3 million hectares or approximately 85% of the catchment and with cattle production accounting for 66% of the total value of agricultural production (ABS 2014 a, b). Three of the four major land types in the region, Brigalow, Alluvial and Open downs, have soils capable of growing high quality forages suitable for backgrounding and finishing cattle. Forages capable of producing the higher growth rates required for backgrounding and finishing include summer and winter annual forage crops and perennial legume–grass pasture systems.

Targeted use of high quality forages has the potential to improve the profitability of beef enterprises in the Fitzroy River catchment of Queensland through increasing enterprise turnover and productivity, and providing a viable alternative to grain finishing for the production of high quality beef. However, in order to achieve a profitable outcome, best practice forage agronomy and management must go together with knowledge of expected cattle performance, expertise in cattle husbandry, feed budgeting, marketing, and an understanding of the financial implications for the business.

This guide brings together information on:

- selection, agronomy and management of suitable forages
- example forage yields across the Fitzroy River catchment
- expected nutrient content of forages and their relationship to cattle performance
- indicative cattle growth rates from a range of high quality forages
- approaches to incorporating high quality forages into feed plans to give the best opportunity to achieve the target growth rates and liveweights required to meet market specifications
- non-nutritional factors that can affect liveweight gain
- example gross margin analysis at key sites across the catchment to provide objective comparisons of various forage options
- spreadsheets to allow calculation of forage gross margins with the user's own input variables
- the effect of sown forages on the whole farm profitability
- data collected from 24 producer co-operator forage sites across the Fitzroy River catchment during 2011–2014.

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ABS (Australian Bureau of Statistics) (2014b) 7503.0 Value of Agricultural Commodities Produced, Australia, 2012-13. Available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7503.02012-13?OpenDocument [Verified November 2014]

2 Why use high quality forages?

Market specifications for high-value beef continue to tighten and trend towards a preference for younger cattle. For these reasons, production systems that enable cattle to be finished more quickly than on native or sown grass pastures are important to increase a beef producer's ability to meet market specifications for high-value beef and to increase turnover of cattle. Both of these aspects may contribute to increased profitability of beef businesses.

In the Fitzroy River catchment of Queensland, opportunities exist to finish cattle in a feedlot or in a 'grain-assist' situation with access to pasture. These options are widely used and offer rapid weight gain and potential marketing advantages. However both systems involve high input costs and may not be economically viable, particularly in years when feed grain prices are high and/or the premium for grain finished cattle is low.

The use of summer and winter annual forage crops, as well as perennial legume–grass pasture systems, has the potential to significantly increase cattle growth rates and provides an alternative to grain feeding.

Benefits

Annual forage crops and perennial legume–grass pastures have the following advantages over native and sown grass-only pastures. They can:

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

Legume–grass pasture systems have additional advantages through their ability to:

- contribute to soil nitrogen levels and halt declining soil fertility in grass pasture systems
- reduce nitrogen fertiliser requirements in subsequent crop rotations when used as short- or long-term leys (burgundy bean and butterfly pea are particularly suited for this purpose)
- enable higher productivity and longer persistence of grasses that have high nitrogen requirements, such as green or Gatton panic, Rhodes and buffel grass.

Other benefits of using high quality annual and perennial forage systems include:

- having more options and flexibility in choosing target markets and timing of turn-off
- reducing grazing pressure on the remainder of the property, allowing pastures to be spelled
- conserving excess forage as hay or silage in good years.

Constraints

Constraints to using high quality forage systems also need to be considered, and include:

- availability of suitable arable land
- the need to purchase, or arrange access to, equipment such as tractors, ploughs, sprayers and planters
- expertise in land preparation, planting and weed control
- costs of crop or pasture establishment failures
- variable seasonal conditions
- difficulties in integrating more intensive forage systems into the business and existing property operations
- uncertainty about the short and long-term profitability of the activity.

The first step when considering planting a high quality forage is to ask the questions:

- Why am I growing the forage?
- What forage type/s are suited to my land and soil type, and production system?
- What is the expected forage and cattle production?
- What is the likelihood of the sown forage improving the profitability of the business?

3 The land resource

Land types

Soil fertility and the water holding capacity are the main characteristics determining the suitability of a soil for forage cropping or planting to high quality legume–grass pastures. To obtain the production potential from high quality forages, they need to be sown on high quality soils. Generally most properties have a number of land types. Broadly speaking, the dominant vegetation and soil type identifies the land type. Figure 1 shows the major land types suitable for high quality pasture and forage crop production in the Fitzroy River catchment. Table 1 summarises the broad suitability and limitations of the major land types for pasture and forage crop production.

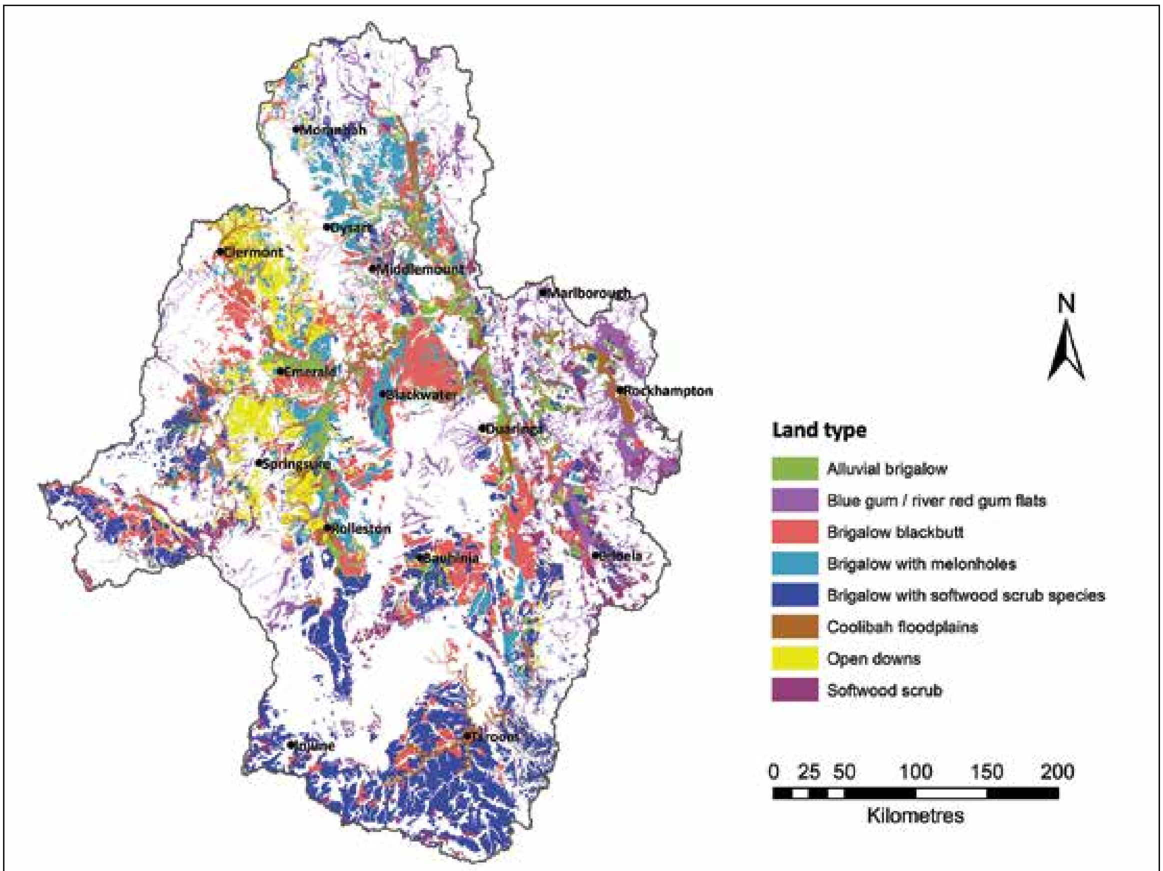

Figure 1. Land types suitable for high quality pasture and forage crop production in the Fitzroy River catchment.

Table 1. Description of major land types in the Fitzroy River catchment suitable for high quality sown pasture and forage crop production

Land type	Land use and management recommendations	Land use limitations	Suitable sown pastures and forages
Brigalow with softwood scrub species			
Soil—dark brown and grey-brown cracking clay (vertosol or dermosol) **soil fertility**: total N moderate, P moderate **water availability:** moderate to high	• suitable for sown pastures • suitable for cropping on soils deeper than 60 cm and on slopes less than 4%	• tree regrowth • salinity • moderate erosion hazard when cultivated	**Grasses** Buffel grass, Gatton, green and bambatsi panic, creeping bluegrass, purple pigeon grass, floren bluegrass **Perennial legumes** Leucaena, butterfly pea, burgundy bean, siratro, caatinga stylo, desmanthus **Annual forage crops** Forage sorghum, lablab, oats
Alluvial brigalow			
Soil—strongly self-mulching black (occasionally grey) cracking clay (black or grey vertosol and dermosol) **soil fertility:** total N moderate to high, P moderate **water availability:** high	• suitable for sown pastures although establishment can be difficult due to coarse self-mulching surface • suitable for cropping, however poor drainage and flooding can lower yields • maintain good ground cover to discourage weed invasion • monitor for overgrazing when grazed in conjunction with other, less fertile, land types	• moderate to poor drainage • occasional flooding • weed invasion • tree regrowth • salinity	**Grasses** Buffel grass, bambatsi panic, creeping bluegrass, purple pigeon grass, floren bluegrass, Rhodes grass **Perennial legumes** Leucaena, butterfly pea, caatinga stylo, desmanthus **Annual forage crops** Forage sorghum, lablab, oats
Brigalow with melonholes			
Soil—gilgaied, brown or grey cracking clay (brown or grey vertosol) **soil fertility:** total N low to moderate, P low to moderate **water availability:** low to moderate	• suitable for sown pastures although establishment can be difficult in melonhole areas • depending on melonhole severity, may not be suited to cultivation	• melonholes • tree regrowth	**Grasses** Buffel grass, bambatsi panic, purple pigeon grass, floren bluegrass, Rhodes grass **Perennial legumes** Leucaena, butterfly pea, caatinga stylo, desmanthus; in paddocks with minor melonholes **Annual forage crops** Forage sorghum, lablab, oats; in paddocks with minor melonholes

Land type	Land use and management recommendations	Land use limitations	Suitable sown pastures and forages
Brigalow with blackbutt (Dawson gum)			
Soil—hard-setting, red to brown, texture-contrast with sodic B horizon (brown sodosol) **soil fertility:** total N low to moderate, P moderate **water availability:** low to moderate	• suitable for sown pastures • not suited to long term cropping • maintain surface cover to reduce sheet erosion, nutrient loss and pasture rundown	• sodic subsoil • poorly drained • hardsetting surface • tree regrowth • weed competition during establishment	**Grasses** Buffel grass, Gatton and green panic, Rhodes grass, sabi grass, digit/finger grasses **Perennial legumes** Shrubby stylo (seca or siran), Caribbean stylo (verano or amiga) in high rainfall areas, caatinga stylo **Annual forage crops** Forage sorghum, lablab, oats
Softwood scrub			
Soil—brown clay (vertosol, chromosol) or deep red clay (ferrosol) **soil fertility:** total N moderate, P moderate **water availability:** moderate (red clays) to high (brown clays)	• suitable for sown pastures • suitable for cropping	• tree regrowth • surface sealing soils after continual cultivation	**Grasses** Buffel grass, Gatton and green panic, creeping bluegrass, floren bluegrass, sabi grass, Rhodes grass (various cultivars) **Perennial legumes** Leucaena, butterfly pea, burgundy bean, siratro, caatinga stylo **Annual forage crops** Forage sorghum, lablab, oats
Blue gum/river red gum flats			
Soil—deep, black cracking clay (vertosol) or deep alluvial loam soil (dermosol) **soil fertility:** total N moderate to high, P moderate to high **water availability:** moderate to high	• suitable for sown pastures • suitable for cropping • only plant Caribbean and shrubby stylos on areas where the soil surface is sandy • disturbance encourages germination of woody plants • monitor for overgrazing when mixed with other, less fertile, land types	• flooding and waterlogging on clay soils • restricted access in wet conditions • weed invasion where regular flooding occurs • erosive flooding in some areas • grass establishment problems on cracking clays and some alluvial loams	**Grasses** Buffel grass, Gatton, green and bambatsi panic, creeping bluegrass, floren bluegrass (on clay soils), Rhodes grass **Perennial legumes** Leucaena (on deeper, well drained areas), butterfly pea, burgundy bean, siratro, caatinga stylo **Annual forage crops** Forage sorghum, lablab, oats; on deeper, more fertile soils

Land type	Land use and management recommendations	Land use limitations	Suitable sown pastures and forages
Coolibah floodplains			
Soil—black cracking clay (vertosol) **soil fertility:** total N moderate, P moderate **water availability:** moderate to high	• suitable for sown pastures although establishment can be difficult • suitable for cropping in areas not subject to regular flooding • soil disturbance encourages germination of woody species • monitor for overgrazing when mixed with other, less fertile, land types	• flooding and waterlogging • salinity and surface cracking • restricted access in wet conditions • weed invasion in frequently flooded areas • erosive flooding in some areas • grass establishment problems with improved pastures due to crusting/cracking or coarse/self-mulching surface	**Grasses** Bambatsi panic, creeping bluegrass, purple pigeon grass, floren bluegrass, Rhodes grass **Perennial legumes** Leucaena, butterfly pea, caatinga stylo, desmanthus **Annual forage crops** Forage sorghum, lablab, oats
Open downs			
Soil—black or brown cracking clay (black or brown vertosol) **soil fertility:** total N low to moderate, P low to moderate **water availability:** moderate to high	• suitable for cropping on soils deeper than 60 cm and on slopes less than 4% • some potential for pasture improvement • to minimise saline seepages, do not clear teatree • maintain surface cover to minimise erosion	• soil erosion hazard when cultivated • rooting depth in some shallow soils • some rockiness • low fertility • grass establishment problems with some small-seeded plants and pastures • high water tables in teatree drainage lines	**Grasses** Bambatsi panic, purple pigeon grass, floren bluegrass, Rhodes grass **Perennial legumes** Leucaena (on deeper soils >90 cm), butterfly pea, caatinga stylo **Annual forage crops** Forage sorghum, lablab, oats; on deeper soils

Adapted from *Land types of Queensland* CD version 1.2, 2008.

Climate

The Fitzroy River catchment is characterised by a sub-tropical, semi-arid climate with high rainfall variability. The amount and distribution of rainfall are primary determinants of pasture and forage growth. Temperature can also be a constraint to growth for some crop and pasture species. Annual rainfall decreases with distance from the coast. The ratio of summer to winter rainfall decreases from north to south, with an average ratio of 70:30. Mean maximum and mean minimum temperatures decrease from north to south with mean daily maxima over 33 °C in January. Frosts occur regularly throughout the region but become more frequent and severe towards the south. For example, Brigalow Research Station near Theodore averages 12.3 frosts (days with ground temperature ≤ –1 °C) annually, whereas Taroom averages 18.2 frosts annually.

Examples of long-term mean and seasonal distribution of rainfall and temperature are shown for three sites across the Fitzroy River catchment, representing the Central Queensland Open Downs region (Emerald-Capella area), the Central Queensland Brigalow region (Biloela–Rolleston area), and the South Queensland Brigalow region (Taroom–Wandoan area), (Table 2). The gross margin analysis for example scenarios presented in Chapter 7 of this guide are also based on these three regions.

Table 2. Long-term mean and seasonal distribution of rainfall and temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall at Capella and temperature at Clermont[A]													
Rainfall (mm)	96.5	96.6	61.2	31.5	29.8	29.7	23.3	17.1	18.4	39.9	56.2	83.0	583.9
Max. temperature (°C)	34.3	33.0	32.0	29.5	26.1	23.1	23.1	25.3	28.8	32.0	34.0	34.9	29.7
Min. temperature (°C)	21.6	21.1	19.4	15.7	11.5	8.1	6.7	8.2	12.1	16.3	19.0	20.8	15.0
Mean No. of days with min. temp. ≤ 2 °C*	0	0	0	0	0.1	2.2	5.0	1.6	0	0	0	0	8.9
Rainfall at Banana and temperature at Brigalow Research Station[B]													
Rainfall (mm)	95.2	96.3	68.1	34.2	35.9	38.0	30.5	22.0	28.8	53.7	68.1	92.2	663.8
Max. temperature (°C)	33.7	32.4	31.7	29.0	25.3	22.1	21.8	23.8	27.2	30.1	31.7	33.2	28.5
Min. temperature (°C)	21.0	20.7	18.7	15.1	11.5	8.0	6.4	7.5	10.9	14.8	17.7	19.8	14.3
Mean No. of days with min. temp. ≤ 2 °C*	0	0	0	0	0.1	2.3	5.4	2.5	0.1	0	0	0	10.4
Rainfall and temperature Taroom[C]													
Rainfall (mm)	97.9	88.5	62.8	35.1	40.5	36.6	33.8	27.6	31.1	55.3	74.1	88.5	671.1
Max. temperature (°C)	33.7	32.8	31.7	28.8	24.5	21.5	21.0	23.0	26.7	29.9	31.8	33.5	28.2
Min. temperature (°C)	20.6	20.4	18.1	14.1	9.7	6.3	5.1	6.5	10.3	14.6	17.5	19.6	13.6
Mean No. of days with min. temp. ≤ 2 °C*	0	0	0	0	0.7	4.6	9.5	5.3	0.7	0	0	0	20.8

A Weather station site for rainfall: Capella Post Office. Records for period 1898–2010. Weather station site for temperature: Clermont Sirius St. Records for period 1910–2010.
B Weather station site for rainfall: Banana Post Office. Records for period 1871–2010. Weather station site for temperature: Brigalow Research Station. Records for period 1968–2010.
C Weather station site: Taroom Post Office. Rainfall records for period 1870–2010; temperature records for period 1952–2010.
* A guide for frost potential.

References and further information

The State of Queensland, Department of Primary Industries and Fisheries 2008 *Land types of Queensland.* CD-ROM Version 1.2. The State of Queensland, Department of Primary Industries and Fisheries, Brisbane.

Bureau of Meteorology: ‹http://www.bom.gov.au/›

4 Planning for profitable beef production from forages

Cattle selection and target markets

Breeds and cattle selection

There can be large variation both between and within groups of cattle in their ability to gain weight. Selection of a uniform group of cattle with high growth rate potential is an important step in successful forage finishing.

Assessing cattle breeds for suitability in reaching target markets or finishing weights is recommended. British breeds and *Bos indicus*–British breed crossbreds finish at lighter weights than European breeds when grazing the same forage. Early-maturing breeds may become too fat for heavier export carcass specifications if they have been grown on high quality feed from weaning. However, late-maturing breeds such as the large European breeds need to grow to a high liveweight before they lay down enough fat for premium markets.

Markets

To achieve good returns, the number of cattle that meet the specifications of the target market must be maximised. Market specifications regularly change and there are differences between processors, hence it is important to check specifications with potential buyers and processors when marketing cattle. Table 3 shows the range of specifications that may apply to beef carcasses.

Table 3. Beef carcass specifications

Accreditation and animal treatment requirements	Major specifications	Minor specifications
Market accreditation e.g. EU, PCAS, MSA HGP status	Sex Dentition Carcass weight Rump fat depth	Meat colour Fat colour Fat distribution Meat pH

Table 4 provides an overview of the major grass-finished cattle markets in Queensland and describes a very broad set of specifications for each market. It must be noted once again that specifications and price points will vary between processors.

Table 4. General beef markets and grading specifications for grassfed product

Market	Carcass specification examples	
Grassfed Ox	**HSCW**: 300–420 kg **Dentition**: 0–8 (priced on 0–4, 5–6 and 7–8) **Fat colour**: 0–4	**Rump fat depth**: 5–22 mm **Butt shape**: A–C **Meat colour**: 1A–4
European Union •	**HSCW**: 240–420 kg **Dentition**: 0–4 **Fat colour**: 0–4 **HGP**: nil	**Rump fat depth**: 5–22 mm **Butt shape**: A–D **Meat colour**: 1B–4
Domestic	**HSCW**: 180–300 kg **Dentition**: 0–2 **Fat colour**: 0–3	**Rump fat depth**: 5–22 mm **Butt shape**: A–C **Meat colour**: 1B–3
MSA • Cattle must meet processor specifications and MSA grading requirements • * These are MSA grading requirements and do not vary	**HSCW**: 180–340 kg **Dentition**: 0–4 **Fat colour**: 0–3* **pH**: 5.3–5.7* **MSA index**: must meet processor requirements	**Rump fat depth**: 5–22 mm **Rib fat depth**: 3 mm+ **Butt shape**: A–C **Meat colour**: 1B–3*
PCAS • Cattle must meet processor specifications and MSA grading requirements • * These are MSA grading requirements and do not vary	**HSCW**: 180–340 kg **Dentition**: 0–4 **Fat colour**: 0–3* **pH**: 5.3–5.7* **HGP**: nil **Grain feeding**: nil **MSA index**: must meet processor requirements	**Rump fat depth**: 6–22 mm **Rib fat depth**: 3 mm+ **Butt shape**: A–C **Meat colour**: 1B–3* **Antibiotics**: nil

Definitions:

Butt shape:	A (very heavy muscling) to E (light muscling); 5 point scale.
Dentition:	number of permanent incisors.
Fat colour:	visually assessed colour of the intermuscular fat lateral to the rib eye muscle; 0 (white) to 9 (yellow); 10 point scale.
Rump fat depth:	mm of fat measured on hot standard carcass at the P8 rump site.
Rib fat depth:	mm of fat measured at quartering site during chiller assessment.
HGP:	hormonal growth promotant.
HSCW:	hot standard carcass weight.
Meat colour:	visually assessed colour of the bloomed loin muscle at the carcass quartering point using AusMeat language; 1A (light) to 7 (dark); 9 point scale.
MSA index:	represents the eating quality potential of a whole carcass; 30 to 80 point scale.

Female cattle

Finishing cull heifers and cows on high quality forage can also be profitable. The potential increase in profit from selling prime females can be greater than for steers due to the greater potential improvement in their market suitability. In addition, females can be slaughtered at lighter weights than males because they reach the desired fat levels earlier, thereby increasing the turnover of cattle. However, while heifers may finish (lay down fat) at a lighter weight than steers their daily gain is usually lower. It is important to assess the profitability of the venture for individual situations. The economic spreadsheet calculators provided with this guide can be used for this purpose.

Backgrounding

High quality forages are often also used for backgrounding cattle prior to feedlot entry. As for finishing operations, backgrounding can be economically risky, so it is important to calculate the gross margin to check that the outcome is likely to be positive. Sensitivity analyses between sale and purchase price and between liveweight gain and cattle price can help assess the riskiness of the venture. The economic spreadsheet calculator provided with this guide can be used for this purpose.

Planning forage needs

In practice, it can be challenging to combine feed sources varying in yield, quality and grazing period to achieve the desired market weight. Developing a lifetime feed plan for cattle destined for premium markets can be beneficial. This will identify whether the target market weights are achievable with the current feed base available on the property. The first step is to identify the existing feed supply and the demand. Once gaps in the feed supply are identified (quality and/or quantity of feed) the next step is to consider the forage options suitable for the land types available and how these could be combined to achieve the growth rates required throughout the year. Tools such as the MLA Feed Demand Calculator, which is free to download from the web, can help calculate and compare the pattern of feed supply and demand on a whole farm basis over 12-months. Figure 2 provides a general guide to the time of year that higher quality green feed is available from key forage options in the Fitzroy River catchment. However, the exact grazing periods will vary from year to year, according to the amount and timing of rainfall, the grazing pressure applied, and location within the region.

Figure 2. Typical feed year calendar of forage options in the Fitzroy River catchment. Green indicates the period of higher quality green feed; blue indicates the period of lesser grazing value in terms of quality, within a forage type. Clear boxes indicate periods of nil grazing value.

Preventing waste

Suboptimal usage of the feed from annual forage crops reduces the profit margins of the forage cropping enterprise. This is especially a problem with forage sorghums which, if underutilised, can rapidly become fibrous and less digestible, thus reducing cattle performance. Strategies that may help to minimise wastage of feed from annual forage crops include:

- staggering the plantings of summer forages
- planting several varieties with different rates of growth
- rotational grazing, using adequate stocking rates to keep the crop vegetative
- closing a section of the paddock for heavier grazing with other available stock to maintain quality
- closing part of the paddock for hay production
- using staggered grazing of the same paddock with cattle requiring the highest quality feed receiving the first grazing. For example, animals closest to finishing (the 'tops' of the mob) graze first, the less finished animals (the 'bottoms' of the mob) graze second and, if appropriate, cows and calves could graze last.

Grazing stubbles and failed grain crops

Animal performance on failed grain crops or stubble is extremely variable and largely dependent on the amount of grain on the crop. Additional feed value can come from grazing broad-leaved weeds amongst the crop and in the headlands. Failed grain crops and stubble can provide valuable forage, particularly at a time when other feed is scarce. However, animal performance can range from gaining weight to losing weight.

Ley pastures

Ley or short-term pasture phases are used in crop rotations to increase soil organic matter and reduce nitrogen fertiliser requirements in subsequent crop phases. Ley pastures are generally a legume–grass mix grown for two to four years. Ley pastures can provide high quality feed suitable for finishing beef cattle but need to establish and grow quickly. They must produce high forage yields with a significant proportion of legume in order to maximise their feed value as well as the amount of organic matter and nitrogen returned to the soil. Some of the most common legume options used in leys are butterfly pea and burgundy bean in central Queensland, and burgundy bean in southern Queensland.

Reducing the proportion of 'non-finishers'

There is variability within every mob of cattle for the time required to reach market specifications. Often a proportion of the mob may not reach the target fat cover or carcass weight and have to be either sold unfinished or carried over onto grass pastures. If this happens, it may take an additional year before there is another opportunity to finish them. Non-finishers reduce the profitability of high quality sown forages. The following are some strategies that may help to minimise the proportion of non-finishers.

Forward condition

It is important to make sure cattle go on to the forage at an adequate weight and condition to allow them to finish in the grazing period. This is particularly important when utilising annual forage crops that have a shorter grazing period, and less room for error, compared with perennial, legume–grass pasture systems.

Stocking rate

Stocking rates need to be a compromise between the most effective use of the crop and the required liveweight gain. If the stocking rate is too high, animals can be forced to eat low quality stem and mature leaf material, reducing liveweight gain per head and the length of time the forage can be grazed. Under these conditions, a higher proportion of the mob may not finish. On the other hand, stocking rates need to be high enough to keep forage crops in a vegetative state (particularly important with forage sorghum crops) and also to optimise liveweight gain per hectare and thus gross margins per hectare.

Supplementation with grain or other energy sources

Providing grain supplements, or other energy supplements such as fortified molasses, to cattle grazing high quality forages is a strategy to improve weight gains and reduce the number of cattle that don't finish. Energy supplements also have the effect of decreasing forage intake per beast due to substitution of some supplement for forage in the diet. This decreases the grazing pressure on the forage, allowing either more stock to graze the same area, or the grazing period to be extended. The profitability of feeding grain or other supplements should be assessed for the specific market prices of grain and cattle at the time of feeding.

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5 Getting the agronomy right and growing the feed

Property resources

Paddock selection

Paddock selection, particularly with regard to soil type, has important implications for profitable forage production. Forages will be most productive when grown on better soils—with high water holding capacity and fertility. Suitable soils include those that:

- produce grain crops
- store moisture to a depth of at least 90 cm—loams, clay-loams and clays are all potentially suitable
- supply adequate amounts of nitrogen, phosphorus, potassium and trace elements.

Plant establishment can be difficult on crusting or hard-setting soils and continual disturbance quickly degrades soil structure. A legume–grass ley can improve soil structure on these soil types.

Soil type variability within potential paddocks is another important consideration, as significant variation in fertility and water holding capacity will make agronomic decisions more difficult and result in variable production across the paddock. Assess potential paddocks for changes in soil type and only develop areas suitable for forage production. However some land types, such as Brigalow, are variable so avoiding problem soil types is not always possible. In these cases, knowing the extent of issues and managing with the variability will provide the most practical outcome.

Floodplains, creek flats and alluvial areas frequently have better quality soils with higher fertility and water holding capacity compared to soils in the uplands and higher ridges. These factors mean greater production potential during the growing season. However, the growing season in these low-lying areas is often shorter due to cooler temperatures in spring and autumn, and frosts in winter. In addition, periodic flooding may reduce forage production and create difficulties for forage and grazing management. All summer forages suited to the Fitzroy River catchment are adapted to tropical conditions, i.e. hot wet summers and mild winters. In southern Queensland the timing of the first frost (May–June) usually signals the end of the growing season for summer forages. In central Queensland growth of summer forages generally slows or stops before the first frost (June–July) due to the decrease in mean daily temperatures and low soil moisture at this time of year.

Infrastructure

On properties where grain cropping is the principal business activity, another important consideration is the availability of suitable infrastructure for cattle management. Unless forages are to be cut and baled or ensiled, the paddock needs suitable fences, water sources and access to yard facilities for adequate cattle management. It is worth thinking about the longevity of fences and other infrastructure that is installed e.g. electric fences can be used for short-term purposes and movable water troughs allow flexibility of use in multiple paddocks.

Rotational grazing of the forages is ideal to maximise their performance but this also requires additional paddock infrastructure. For example, leucaena–grass pastures are most productive under a rotational grazing system using a number of smaller paddocks.

The ability to muster cattle and easy access to yards is important, particularly to make the most of marketing opportunities as they arise. This might mean installing infrastructure such as lane-ways, stock water sources outside the paddock, and spear-trap gates onto water. For the timely marketing of stock during wet periods livestock carriers require all-weather access to the yards.

Machinery

The available equipment—either owned, locally for hire, or through contractors—will dictate whether, and how, forages are grown. High quality forages can be successfully grown in either conventionally cultivated or zero till (no cultivation) situations. The type of planter available will have a significant bearing on what tillage system can be used. For example, if a narrow tyne combine planter is the only sowing equipment available, preparation of a fully cultivated seedbed is required by either chisel ploughs, scarifiers or offset discs. If a planter is available that can direct-drill into undisturbed soil, tillage prior to sowing is not required. In this instance weeds can be controlled by herbicides. Using spray-rigs for weed control requires knowledge of application techniques including drift management, product and rate selection, and how to time spraying for optimum effectiveness. However, if cattle have grazed a previous forage crop, substantial soil compaction may have occurred, especially if the soil was wet late in the grazing period. In this instance, some cultivation might be required to enable timely sowing of the following crop.

Dealing with soil compaction can be a major consideration. In conventionally cultivated situations, deep tillage is often required (particularly on non-cracking soils) to remediate compacted soil layers resulting from either animal traffic during wet periods or machinery used in cutting, baling and ensiling operations. However, deep tillage delays the accumulation of soil water necessary for successful subsequent crops. Although zero tillage systems can potentially accumulate soil moisture more quickly than under conventional cultivation, limiting compaction damage in zero tillage systems is more difficult and often a return to a cultivated fallow is required when compaction is severe.

Basic principles

Preparation and timeliness

The key to successful forage production is the same as for grain production: preparation and timeliness. Plan the forage program well in advance of sowing. Before sowing it is important to plan for and, where practical, address issues such as ensuring the soil surface condition will support vigorous establishment, and responding to weed pressure and nutrient deficiencies. Planning for in-crop weed control is also very important, as inadequate control is often a major contributor to poor forage production. Weeds easily compete with a young, establishing forage crop (especially legumes) if not controlled before sowing or if rain falls soon after planting. This means determining which in-crop herbicide can be used for the potential weed spectrum before sowing. Sowing forage mixtures such as forage sorghum and lablab together will significantly limit herbicide options for weed control, so the best strategy is to control the weeds in the previous crops, manage weeds during the fallow period prior to planting and establish a dense, competitive forage crop. It is also critical that herbicide rates are used according to label directions for the weed species and size. Producers should seek professional advice in this area to maximise the benefits of herbicide application.

Ensure the soil is sampled well in advance of planting to allow adequate time to plan for fertiliser application, if necessary. This is particularly important for annual forages such as oats, forage sorghum and lablab due to the short growth period and high biomass production. The process of soil sampling, testing, interpretation and product selection can take several weeks to complete so it is critical that sampling is conducted well before planting. Local agronomists with the right equipment (hand auger or corer, soil tubes, cutting tray) can undertake sampling. It is important to ensure a representative soil sample, from the top (0–10 cm), middle (10–30 and 30–60 cm) and subsoil (60–90 cm) strata, is collected in each paddock. If different soils types are present collect separate samples from each area. For cereal forages (e.g. forage oats, wheat and sorghum) the main nutrients to assess, in order of importance are nitrogen, phosphorus, sulphur, potassium and the trace elements such as zinc. The main nutrients of importance for forage legumes are phosphorus, sulphur, zinc and potassium. Collected soil samples should be sent to a nutrient analysis laboratory immediately and the results interpreted by a trained agronomist.

Determining nutrient requirements and applying adequate fertilise prior to, or at, planting is easier than after the crop is growing. Except in irrigated situations, fertiliser is rarely applied in-crop as rainfall to incorporate and ensure root uptake cannot be accurately predicted and it can be difficult to apply when forages are tall, resulting in a high risk of obtaining an un-economic response.

Establishment and associated risks

The old saying 'you reap what you sow' is very pertinent to forage production. The planting and establishment phases are the most critical to the success of forage production—get this wrong and production will only be a fraction of the plant's potential, and weed and grazing management will be very difficult. Patchy establishment encourages weeds to take over and the forage will be uneven in height or maturity making it difficult to ascertain the optimal timing of grazing or cutting.

Rainfall in the Fitzroy River catchment of Queensland, while summer dominant, is highly variable. Also, temperatures above 35 °C can occur for days and potentially weeks on end, depleting valuable soil water during long fallow periods, or when young forage crops are establishing. To minimise the risk of establishment failures in dryland situations, only sow when there is greater than 75 cm of wet soil and a chance of follow-up rainfall. Sowing summer forages should occur between December and late February, depending on the forage species and intended use. Sow winter forages such as oats, forage wheat or barley no earlier than April in central Queensland and March in southern Queensland, and on 90 cm of soil moisture due to the lower probability of receiving in-crop rainfall.

When establishing ley-pastures with small seeded grasses, multiple cultivations which produce a soft seedbed can be a hindrance rather than a help. A firm seedbed will have soil moisture closer to the surface, while the soil surface of a fully cultivated seedbed will dry more quickly. Ploughing is necessary to alleviate severe compaction and remove excess stubble but using herbicides will frequently be a better method of controlling weeds than cultivation, especially in self mulching soils (e.g. Open Downs). Soft cultivation may also cause the seed to be planted too deep. As a rough rule of thumb, if the heel of your boot sinks in, your soil may already be too soft and fluffy. As a result the soil surface is likely to dry quickly before the seed germinates and establishes. Use a roller to ensure good soil-seed contact.

When growing legumes, it is essential to inoculate legume seed with the correct Rhizobium strain to ensure effective nodulation. Without effective nodulation, nitrogen fixation will not occur, significantly reducing the benefits provided by the legume. Generally, most tropical legumes are inoculated with peat rhizobium. It is critical to ensure the rhizobium is within its expiry date, stored in a cool environment (such as the refrigerator) before use, and mixed with the seed (slurry technique with water as per the directions) just prior to sowing. Heat and dry conditions reduce the life expectancy of the rhizobium bacteria and so seed needs to be sown, within hours of coating, into the soil with good moisture to maximise bacteria survival and nodulation. Some legume seeds are sold pre-coated with inoculum, and so it's important to determine how long the seed has been coated for to determine the potential viability of the rhizobium.

Monitoring and managing

The key message is: do not plant the crop and walk away until cattle are introduced. There are a number of factors that need to be monitored to get the most out of what has been sown. During the establishment phase growers should:

- inspect the paddock and undertake required weed control measures
- monitor soil insect pests such as false wireworms, cutworms and armyworms that can have devastating impacts on plant populations and subsequent production
- monitor the growth of the crop so that cattle can be introduced at the right stage to maximise both forage production and animal performance. Refer to the next section for specific grazing management recommendations for each forage type.

Selecting the most appropriate forage species

There are a number of high quality forages suitable for the productive soils of the Fitzroy River catchment of Queensland. The main forages commonly utilised include:

- perennial, legume–grass pastures: butterfly pea–grass and leucaena–grass
- summer forages: forage sorghum and lablab
- winter forages: oats.

Perennial, legume–grass pastures:

Butterfly pea (*Clitoria ternatea*) + grass species

Butterfly pea is a tropical, perennial forage legume suited to short-term ley-pastures (approximately 5 years) or medium-term permanent pastures. It performs best in climates with wet, hot summers and mild winters. Butterfly pea is frost sensitive but will regrow in the following spring and summer. The growing season is from spring to late autumn (soil moisture dependant) and provides high quality forage material enabling high animal performance (0.8–1.2 kg/head/day) during the peak growing season.

Benefits

- Perennial legume that persists for many years on a range of soil types although it is best suited to clay soils due to their higher water holding capacity
- Easily established due to its large seed and can be sown with conventional crop sowing equipment
- Prolific producer of high-dormancy seed enabling seedling recruitment over a number of years, although this may cause problems in following crops
- Produces good amounts of highly palatable forage with crude protein concentrations typically between 19–27% in green leaves and fine stems
- Contributes to soil nitrogen levels, halting soil fertility decline and improves the quality of companion grass
- Very few insect pests (soil or plant)
- Tolerates periodic heavy grazing and dry periods
- No bloat concerns
- Can be removed to recommence a cropping program using either cultivation or herbicides and so is highly suited to a ley-pasture system.

Constraints

- Low production and persistence on soils with low fertility and/or water holding capacity
- Seed needs to be scarified for adequate germination and even establishment, especially when sown into a prepared seedbed
- Seedlings are slow to establish and compete poorly with other plants like grasses and broadleaf weeds so timing of weed control is critical
- Frost or low temperature (<15 °C mean daily temperature) restricts the growing season and, compared to grasses, butterfly pea can be slow to regrow after winter, particularly if soil moisture is marginal
- Rotational grazing management with rest periods is required for long-term persistence.

Establishment

- **Planting situations—**sow butterfly pea into either fallow or existing grass situations where a perennial legume is required to restore soil fertility and improve the diet quality available to cattle.
- **Sowing methods—**similar to annual forages or grain crops, butterfly pea can be sown with either conventional tillage sowing equipment (e.g. combine, air seeder) or into standing stubble with zero tillage planting equipment.
- **Sowing time, rate and depth—**the best sowing time is during summer (December to March) provided there is 75 cm of soil moisture and the chance of follow-up rainfall. Sowing at this time provides better opportunity for the plant to produce a woody structure and produce seed before the first frost. However, butterfly pea can be sown earlier into fully wet soil profiles. An adequate plant population will require 7–10 kg/ha of seed to be sown, although rates of 12–15 kg/ha can provide greater weed suppression and maximum forage production in shorter periods of time. Best establishment will occur when seed is planted no deeper than 5 cm and into moist soil.
- **Seed treatments—**for effective nodulation and nitrogen fixation, butterfly pea seed must be inoculated with Group 'M' inoculant at planting time.

Nutrition

- **Nutrient requirements—**like most legumes, butterfly pea requires adequate amounts of phosphorus, sulphur, zinc and other trace elements for effective nitrogen fixation and biomass production.
- **Application rates and timing—**if a soil test indicates phosphorus levels are below 10 mg/kg, around 50 kg/ha of 'starter' type fertiliser (including phosphorus and zinc) at planting will improve biomass production and nitrogen fixation.

Pests

- **Weed control—**butterfly pea seedlings are susceptible to competition so early weed control is very important. In paddocks where high weed numbers occur, apply a residual herbicide prior to planting (or post emergent) to control broadleaf and grass weeds for 3–6 months. Also, sowing on narrow rows (25–40 cm) at a high seeding rate can maximise competitiveness of butterfly pea.
- **Insects—**no control warranted.
- **Diseases—**no known diseases.

Growth pattern and timing of seasonal production

Growth will start in late September or early October and continue into late autumn, dependant on soil moisture and warm temperatures. However generally, high quality feed is produced from early summer up to the first frost.

Managing grazing to maximise plant productivity

Young butterfly pea seedlings will die if subjected to constant heavy grazing. Allow a new stand to set seed in the first year after sowing. This practice ensures sufficient seed for future regeneration and the development of a woody frame, providing improved grazing tolerance. Grazing can occur once sufficient biomass is produced and growth will continue while sufficient moisture is present and average daily temperatures are greater than 15 °C. Diet quality will remain high even after the plant flowers as leaves are produced throughout the flowering and pod-filling stages. Sowing a mixture of grasses with butterfly pea will provide a productive, long-term pasture. Grasses utilise the nitrogen that butterfly pea produces, stimulating the butterfly pea to produce more nitrogen. The grass component of the pasture extends feed availability and provides both additional forage dry matter and ground cover between the legume plants, reducing weeds in the pasture and improving overall production.

Leucaena (***Leucaena leucocephala*** spp. ***glabrata***) + grass species

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

Benefits

- Highly productive, perennial legume
- Can persist on a range of soil types for more than 30 years
- Produces highly palatable forage that is high in protein (15–33% crude protein in green leaves and fine stems)
- When grown with a productive grass, high stocking rates (1 AE / 1:5 ha) and total cattle weight gain greater than 250 kg/AE/annum are possible
- No bloat concerns
- Deep root system allows the plant to continue growing into dry periods and minimises deep drainage
- Contributes to soil nitrogen levels, halting soil fertility decline and improves the quality of companion grass.

Constraints

- Requires significant management effort to achieve adequate establishment
- Low production and persistence on shallow and low fertility soils due to high soil water and nutrient (phosphorus) requirement
- The growing season stops when average daily temperature falls below 12 °C
- Psyllids (small, sap-sucking insects) can reduce production, particularly in coastal areas or during periods of mild (<35 °C), humid weather
- Cattle need to be drenched with the leucaena rumen fluid inoculum to prevent mimosine and dihydroxypyridine (DHP) toxicity. If not effectively protected cattle will suffer reduced weight gains and can even die in extreme situations
- Needs intensive grazing management to maximise production, and to minimise seed set and the potential for rogue plants to establish outside the planted area.

Establishment

- **Planting situations—**leucaena is suited to situations where a permanent legume is desired to improve animal performance.
- **Sowing methods—**leucaena can be sown into either existing cultivation or grass paddocks. If leucaena is sown into an established grass paddock, remove either all the grass or 5 m wide grass strips, using cultivation or herbicide, leaving 3–5 m strips of grass.

- **Sowing time, rate and depth**—sow leucaena from September through to February. The best time to sow is once the soil profile has more than 75 cm of moisture and the probability of follow-up rain is highest. This means summer is the most suitable sowing period. Seed should be sown at 2 kg/ha and deeply enough for moisture to persist around the seed for 5–7 days, but no deeper than 5cm
- **Seed treatments**—leucaena needs to be inoculated with 'desmanthus/leucaena rhizobium' (or strain CB3126) to ensure effective nodulation and nitrogen fixation.
- **Obtain specific establishment advice**—leucaena can be challenging to establish so it is recommended that first time growers seek advice through courses provided by The Leucaena Network.

Nutrition

- **Nutrient requirements**—leucaena performs best on soils high in phosphorus, sulphur, potassium and trace elements.
- **Application rates and timing**—a soil test should be taken to identify nutrient limitations. To ensure healthy, vigorous seedlings and a productive plant stand where phosphorus levels are low (<20 mg/kg), an application of at least 50 kg/ha of a starter type fertiliser (which includes phosphorus) is recommended at planting.

Pests

- **Weed control**—leucaena is a slow and non-competitive seedling so weed control prior to and after planting is critical. Control weeds prior to planting using cultivation and/or herbicides. A residual herbicide (e.g. Imazethapyr) post-planting is effective to control broadleaf weeds and some grasses for up to six months.
- **Insects**—soil insects can affect the establishment of seedlings and there are a number of effective products available. In addition, psyllids can devastate established stands during mild, humid conditions. Psyllids can be treated with a systemic insecticide such as dimethoate, and this is generally more cost effective for young, establishing stands.
- **Diseases**—leucaena is relatively disease-free. However, leucaena does not tolerate prolonged water-logging and so soil borne diseases (e.g. phytophthora) might reduce production in poorly drained, heavy clay soils.

Growth pattern and timing of seasonal production

Leucaena prefers hot, wet conditions and therefore grows most during the spring and summer months, ceasing in autumn when either soil moisture is depleted or average daily temperatures fall below 12 °C. Grazing can commence in spring once sufficient biomass is present, and must start before flowering commences to maximise grazing value and minimise seed set.

Managing grazing to maximise plant productivity

In the first year, grazing should commence once the majority of the plants are more than 1.5 m tall. Grazing earlier can stunt the plant, lowering future production. Once established (second year onward), rotationally graze leucaena to maximise its production and keep the plants to a maximum height of 2 m. This strategy also minimises the likelihood of the plants setting seed and spreading from the intended growing area, and the need for mechanical trimming. It is highly recommended that leucaena growers follow the 'Code of Practice', developed by The Leucaena Network, to maximise production while minimising the potential spread of leucaena. The Code of Practice can be found at www.leucaena.net. In addition, the MLA published book '*Leucaena: a guide to establishment and management*' provides further valuable management recommendations.

Summer forage:

Forage sorghum (*Sorghum* spp.)

Forage sorghum is a popular forage due to its high biomass production, wide planting window and growing season and its suitability to a range of soil types. It is relatively drought hardy but high moisture is needed to maximise production. The quality of feed produced (digestibility and protein) can vary and is dependent on soil fertility, fertiliser used and the variety sown. Forage sorghum can be grazed at high stocking rates. However, individual animal performance is typically lower on forage sorghum compared to some other sown forage types.

Benefits

- Suitable for a range of soil types
- Wide planting window and growing season
- A range of varieties are available to meet a large range of feeding objectives
- Drought tolerant
- High biomass production
- Rapid recovery after grazing or cutting if there is adequate soil moisture.

Constraints

- Requires good moisture and high nutrient supply to maximise quantity and quality of biomass produced
- Frost susceptible
- Disease (ergot) can be a problem late in the season
- The build up of prussic acid in moisture-stressed crops, particularly young or regrowing crops, can result in reduced animal performance and, in severe cases, can cause fatalities
- Individual animal performance may not be as high as other sown forage types
- Intensive grazing management is required to minimise wastage
- Can rapidly grow past the optimum stage to graze resulting in large quantities of low quality forage.

Establishment

- **Planting situations—**forage sorghum is an annual crop that can provide feed during the spring, summer and autumn periods, depending on planting time.
- **Sowing methods—**plant forage sorghum into a conventionally-tilled seedbed or with a zero till seeder into stubble.
- **Sowing time, rate and depth—**the planting window extends from early September to February. However, sowing commonly occurs in early summer due to soil temperature (17 °C and rising) and moisture requirements (at least 60 cm of soil moisture). Late planted crops have a greater risk of ergot infection and need to be managed appropriately. Sowing rate ranges from

4–8 kg/ha depending on moisture availability, i.e. higher rates with irrigation. The seed should be sown at a depth between 3 and 5 cm and into soil moisture. Presswheels significantly improve establishment rate and uniformity.

- **Seed treatments**—are usually not warranted. However, 'beetle bait' or seed treated with insecticide is important where soil insects are a problem. Also, if using herbicides that include s-metalochlor (e.g. Dual Gold®) to control weeds, the seed needs to be treated with Concept II® seed safener to avoid damaging the crop.

Nutrition

- **Nutrient requirements**—for every tonne of biomass produced, around 25 kg/ha of nitrogen, 3 kg/ha of phosphorus, 17 kg/ha potassium and 2 kg/ha of sulphur are required. If a crop produces 10 t/ha of biomass, then 250 kg/ha of nitrogen is needed (either supplied from the soil reserves or fertiliser).
- **Application rates and timing**—fertiliser rates will depend on soil fertility, available moisture and the level of production required. Where a soil test indicates nitrogen deficiency and or high output is required, nitrogen rates in excess of 100 kg/ha may be required. In dryland situations, fertiliser is best applied pre-plant or at planting (placement away from the seed is required to eliminate seed burn at high rates) due to the difficulties and variable responses achieved applying fertiliser in-crop. Long-term hay or silage production in the same paddock will mean greater nutrient removal as the entire crop is taken off the paddock. In these cases higher fertiliser rates than those used in a grazed situation are required to avoid rapid nutrient run-down.

Pests

- **Weed control**—weed control is required in the fallow using either herbicides or tillage, and in-crop using herbicides. Early in-crop weed control is critical to achieve potential biomass production. Control grass and broadleaf weeds using specific herbicides. Obtain agronomic advice to tailor control options to specific situations.
- **Insects**—in young, establishing crops soil insects such as cutworms and wireworms can cause damage. Control these pests with seed treatments or 'beetle bait'. Generally soil insects are of little concern in established crops.
- **Diseases**—ergot is the main disease that affects forage sorghum with infection occurring when plants flower during cool (<25 °C), humid conditions. Crops flowering late in the season (autumn or early winter) are the most susceptible. Ergot pollinates the ovary and initially produces an oozing honey dew, then a sclerote forms instead of a seed. Ergot infection does not reduce the amount of feed (leaf and stem) produced. However, animal performance can be impeded if cattle preferentially graze seed-heads.

Growth pattern and timing of seasonal production

Forage sorghum grows very quickly under ideal conditions. First grazing can occur at 6–8 weeks of age and regrowth is rapid. Depending on sowing time and soil moisture, grazing can occur periodically throughout the summer and autumn period. The first frost will end the growing season, usually in June. Some varieties such as the sweet sorghums have the ability to overwinter.

Managing grazing to maximise plant productivity

Forage sorghum can rapidly grow past the optimum stage to graze, resulting in large quantities of low quality forage. Therefore grazing management (timing and number of animals) is important for maximising individual animal weight gain as well as forage utilisation and cattle production from the crop. Cattle should be introduced when the crop is around 1 m high and removed before the crop is grazed below 15 cm. Rotational grazing strategies can be useful for managing grazing pressure. Sweet sorghums, or varieties that are used for autumn and early winter feed, can be left longer before commencing grazing due to the higher palatability (or sweetness) of stems.

Lablab (*Lablab purpureus*)

Lablab is an annual forage legume that produces high quality forage suitable for finishing cattle. Lablab is best sown on its own and early in the summer period. Depending on soil moisture and timing of the first frost, lablab will provide high quality feed into autumn and winter. Cattle can gain more than 1 kg/head/day in the peak growing period and, if the crop has been sown on good soil moisture with follow-up rainfall, they can perform at this level for a number of weeks.

Benefits

- Large seed provides relatively easy establishment
- Produces quality feed (highly digestible, high crude protein)
- The most productive annual forage legume available. Has the ability to regrow after grazing or cutting
- Can supply high quality forage when grasses are mature and quality has declined (e.g. in autumn)
- With effective rhizobium nodulation, lablab can contribute large amounts of nitrogen to the soil which is available for use by subsequent crops
- With careful management in the first year (i.e. grazing to prevent flowering and seed set) lablab may regrow and can be grazed in the second season.

Constraints

- Soils with low levels of phosphorus need to be fertilised to obtain optimum growth and subsequent nitrogen contribution
- Highly frost sensitive. Leaves die and fall within two days of frosting. Leaves of other tropical legumes take up to a week to fall
- Cattle may take 2–5 days to acquire a taste for lablab forage and suffer slight weight loss unless access to grass is available either on headlands or in an adjoining paddock
- Lower carrying capacity and slower regrowth compared to forage sorghum.

Establishment

- **Planting situations—**planting should occur as soon as the risk of frost is passed and 75 cm of soil moisture is present.
- **Sowing methods—**plant lablab either into a conventionally-cultivated seedbed or in zero tillage situations.

- **Sowing time, rate and depth**—sowing can occur any time between September and February. Sowing prior to Christmas enables higher forage production and more grazing time if follow-up rainfall is adequate. Sowing seed into moisture between 3 and 5 cm deep at 20–30 kg/ha is usually sufficient for a productive crop. For crops planted in February, use the higher planting rate to maximise forage production.
- **Seed treatments**—lablab seed needs to be inoculated with 'J' strain rhizobium for effective nodulation and nitrogen fixation.

Nutrition

- **Nutrient requirements**—if effectively nodulated, nitrogen fertiliser is not required. Phosphorus, sulphur and zinc are important for nitrogen fixation, vigorous growth and high biomass yields.
- **Application rates and timing**—if soil nutrient status is unknown, conduct a soil test. If phosphorus is low, apply 50 kg/ha of a starter-type fertiliser at planting to improve production and nitrogen fixation.

Pests

- **Weed control**—broadleaf and grass weeds can significantly lower biomass production, particularly if weeds are competing with young seedlings. Lablab is relatively slow to establish. Sowing in narrower rows at a high seeding rate does assist with weed competition but this alone is unlikely to provide adequate control in weedy situations. A number of pre-emergent herbicides are available for grass and broadleaf weed control. However, in-crop herbicide options are limited. Options are very limited when lablab is sown with another crop, for example, forage sorghum. Seek specific agronomic advice.
- **Insects**—insect control is not generally warranted. However, if planting late (i.e. February) bean fly can attack young seedlings.
- **Diseases**—lablab is sensitive to phytophthora root rot, which occurs in heavier soils where water-logging occurs.

Growth pattern and timing of seasonal production

Lablab is late flowering and will provide good quantities of biomass and hence grazing value through summer and into late autumn, depending on available soil moisture.

Managing grazing to maximise plant productivity

Grazing can commence around 10 weeks after sowing. However it is important that the plant is at least 45 cm high to ensure an adequate plant frame and enough leaf have been produced. Ideally, cattle should be removed once all leaf and small stems have been consumed, as this will provide rapid recovery and provide another grazing after a short rest period if sufficient moisture is available. This management regime will provide the best opportunity for the crop to survive into a second year, particularly if grazing pressure prevents flowering and pod set.

Winter forage:

Oats (*Avena sativa*)

Oats is the most widely used winter forage due to its high forage production and quality of feed. Oats is productive at the time of the year when native and sown grass pastures are dormant, enabling good weight gains when cattle would otherwise be maintaining or losing weight. Oats can provide feed from winter through to early spring, with spring heat and low soil moisture dictating the length of the season. In good seasons, two to three grazings can be achieved however low winter rainfall causes missed planting in some years and low production in others.

Benefits

- Relatively simple crop to grow with large seed that establishes easily
- Produces high quality and quantity of forage at a time when grass pastures are dormant and of low quality
- Long growing season when follow-up rain occurs
- Individual animal performance is high and high stocking rates are possible in good seasons.

Constraints

- For maximum production, oats needs to be fertilised with nitrogen, particularly if grown on long-term forage or cropping country
- Oats is rust susceptible. Leaf rust-resistant varieties are available. Resistance often breaks down after a few years because of changes in rust races. Seed of rust-resistant varieties may need to be ordered early and is more expensive
- Oats cannot be sown too early, (March in central Queensland), because high soil temperatures (>25 °C) at sowing depth can reduce germination and establishment
- Unreliable autumn/winter rainfall, especially in the northern part of the Fitzroy basin increases the risk of missing a planting opportunity, or low dry matter production. For example, the years with suitable rainfall for sowing oats ranged from 67% at Taroom and Banana to 62% at Capella (based on modelling using historical rainfall records for the last 108 years)
- Although some producers have observed that cattle appear to perform better if given access to either hay or a dry grass paddock while grazing oats, there is no scientific evidence available to support this recommendation.

Establishment

- **Planting situations—**oats can be sown once 90 cm of soil moisture is stored and soil temperatures at seed depth are 15–25 °C.
- **Sowing methods—**sow oats using either conventional seeders into a cultivated seedbed or by zero tilling into stubble.

- **Sowing time, rate and depth—**in central Queensland, do not plant oats before the first week in April due to high soil temperatures (above 25 °C) at sowing depth. High temperatures shorten the coleoptile (initial shoot from the seed) length and this significantly reduces the establishment rate. Oats can be sown in late March in southern Queensland. The recommended planting rate is 30–50 kg/ha. Adjust planting rate for germination, seed size and percentage establishment in the field. There are approximately 50 000 seeds per kg, but always check the seed container for the correct seed size and germination. Seed is best sown at 5–7.5 cm depth in row spacings of 18–25 cm. Oats has a longer coleoptile than wheat and barley and is suitable for deep sowing using moisture-seeking tynes.
- **Seed treatments—**none recommended.

Nutrition

- **Nutrient requirements—**forage oats producing 1 t/ha of dry matter with a protein content of 22% will remove 35 kg/ha of nitrogen, so nitrogen application is usually required on paddocks with long forage history. Phosphorus and zinc are also essential nutrients for a productive oats crop.
- **Application rates and timing—**a soil test is recommended to determine the amount of fertiliser required. If 90 cm of soil moisture is present, up to 50 kg/ha of nitrogen could be required to maximise production. Phosphorus should be applied in deficient situations at around 40 kg/ha of product, for example, MAP (mono-ammonium phosphate) or DAP (diammonium phosphate). In general, nutrition requirement and fertiliser rates are similar to those recommended for wheat and barley.

Pests

- **Weed control—**correct weed control is critical for a productive oats crop. A number of herbicides are registered for use with oats. However some herbicides such as ‘2,4-D’ can have adverse effects at high rates with particular varieties.
- **Insects—**no significant issues with insects.
- **Diseases—**the most significant diseases are stem and leaf rust. For grazing purposes, leaf rust is the most important. Currently only two or three varieties have significant resistance. These varieties sell first, so order early to secure your seed. All available varieties are susceptible to stem rust, although stem rust is only of practical concern if using the crop for hay or grain. Several fungicides (e.g. Tilt, Folicur) are registered for control of leaf and stem rust in oats crops in Queensland. In most grazing situations, application of a fungicide is unlikely to be economically viable. Fungicide application may be economic for irrigated, high-value hay crops and seed crops, especially for control of stem rust.

Growth pattern and timing of seasonal production

The main production period, or grazing time, is from June to September but will depend on planting time, soil moisture, temperature and grazing regime. Plant growth and hence grazing can extend into late spring under favourable conditions (cool temperatures, good soil moisture, light grazing pressure).

Managing grazing to maximise plant productivity

To maximise productivity, oats should be grazed then rested. However, in practice the amount and timing of in-crop rainfall greatly influences grazing management. Multiple grazings will be achieved if grazing commences after secondary roots have established, and before the stems begin to elongate. Adequate nitrogen application at planting will also increase the speed of recovery, reduce tiller death and increase overall forage yield. For rapid regrowth, graze oats no lower than 12–15 cm. Grazing below this height can remove the growing points and delay subsequent regrowth. If leaf rust infection occurs graze the crop heavily to reduce the losses before the disease becomes severe. Also, subsequent regrowth will occur later when the temperature is likely to be lower and less conducive to leaf rust development. The new growth will likely remain free of symptoms for several weeks, and should be grazed lightly and often.

Alternative forage options:

Silk sorghum (*Sorghum* spp.)

Silk sorghum has been a popular forage crop because the seed is cheap and it is easy to establish. If conservatively stocked with adequate soil nitrogen supply, it can persist for 3–5 years and produce moderate to high forage yields. Annual forage sorghum varieties produce higher forage yields but only survive for one season. Silk sorghum is closely related to Johnson grass so there is a risk of getting this seed when purchasing silk sorghum. Silk sorghum has high weed potential and should not be planted on cropping soils. For high-output forage production situations, forage sorghum varieties are the preferred option. Silk sorghum can be productive in the right situations with careful grazing management.

Cowpea (*Vigna unguiculata*)

Cowpea is a summer-growing, annual forage legume that provides high quality forage. Only one grazing is possible as regrowth is poor. It is not as productive as lablab that has the ability to allow multiple grazings under the right soil moisture conditions. Most cowpea varieties are susceptible to root rot diseases when growing in water-logging conditions, the exception being 'Red Caloona'. This variety has root rot resistance and so is a good option where water-logging is possible.

Forage wheat (*Tricticum aestivum*), barley (*Hordeum vulgare*) and millet (*Pennisetum* and *Echinochloa* spp.)

A number of other forage cereal crops are available which can provide high quality forage. These include forage wheat, barley and millets. Forage wheat and barley provide feed at a similar time of the year to oats, whereas millet provides feed at a similar time to forage sorghum.

Forage wheats are adaptable to a range of situations because they are highly palatable and have a wide sowing window. They are also more resistant to leaf and stem rusts than forage oats. Compared to oats they are a minor crop due to relatively unknown performance and poorer regrowth potential after grazing. Forage wheat produces similar biomass yields to oats up to the first grazing, but subsequent regrowth is much lower. Forage wheat is usually planted for hay rather than for grazing.

Forage barley produces high quality forage suitable for grazing, hay or silage production. Under favourable conditions forage yield is similar to oats up to the first grazing but regrowth is much lower. Forage yield can be higher than oats if planting in the cooler months of May and June. The grazing period for forage barley is shorter due to the later sowing time (shorter coleoptile) and earlier maturity, where unpalatable seed-heads and awns increase wastage. Barley varieties have better resistance to rust than oats but are susceptible to other diseases (e.g. blotches) that can restrict grazing.

Forage millets are summer-productive forages that belong to the *Pennisetum* and *Echinochloa* genus of grasses. *Pennisetum* types provide forage at similar times of the year to forage sorghum, and while they do not produce as much plant material, feed quality is higher due to finer stems. The seed size is small so uniform establishment on clay soils can be difficult. In this situation, rubber tyre rollers, or preferably press-wheels, are essential for adequate establishment. Other advantages of forage millet (when compared with forage sorghum) include significantly faster regrowth providing shorter intervals between grazing and no prussic acid production, reducing the risk of fatalities particularly during water stress situations. *Echinochloa* types (Japanese, Shirohie, Siberian) are more suited to southern Queensland and northern New South Wales, as the hotter summer temperatures experienced in central Queensland induces earlier flowering, reducing biomass production. However these millets can provide feed very early in the season due to the suitability for early spring sowing.

Burgundy bean (*Macroptilium bracteatum*)

Burgundy bean is a short-term, perennial forage legume well suited to the clay soils in the Fitzroy River catchment. Burgundy bean is highly productive in the first year. However, due to high palatability and short plant life it usually only persists for 2-3 years. Under central Queensland conditions it is as productive as butterfly pea in the first couple of years. However butterfly pea is more productive (due to longer plant life) in the longer term.

Stylos: Seca and Siran (*Stylosanthes scabra*), Verano and Amiga (*Stylosanthes hamata*), and Caatinga (*Stylosanthes seabrana*)

Plants in the stylo group are suited to permanent pasture situations where a persistent, long-term legume is required. They are not as productive as other perennial pasture legumes such as butterfly pea, leucaena or burgundy bean, but this is mainly due to being suited to the poorer quality (low water holding capacity and fertility) soils. They will persist under moderate grazing pressure.

Shrubby stylos (i.e. Seca and Siran) are relatively slow to establish but are widely adapted to tropical environments on a range of soils except heavy clays. They are highly adapted to and persistent on eucalypt woodland soils with low soil phosphorus, where animal weight gain can be increased by around 35 kg/year. Caribbean stylos (Verano and Amiga) are more productive and better suited to the wetter (north and coastal) regions, whereas the Shrubby types are more productive in lower rainfall regions due to better drought tolerance. Caatinga is the only stylo suited to clay soils, where it can be productive and persistent for more than ten years. Caatinga also has better cold tolerance making it more suitable to the southern areas compared to the Shrubby or Caribbean types. However seed availability has been variable in recent years, and specific rhizobium requirement makes nodulation problematic if broadcasting onto unprepared seedbeds.

Desmanthus (*Desmanthus virgatus*)

Desmanthus is another forage legume suited to a range of soil types in permanent pastures. It is very persistent and productive on heavy clays soils and will provide high protein forage in situations where other legumes will not persist, for example, on heavy brigalow soils with melon-holes. Like the stylos, desmanthus is not as productive in the short term as butterfly pea and burgundy bean but will persist longer in a permanent pasture.

Lucerne (*Medicago sativa*)

Lucerne is a temperate legume also suited to the sub-tropics and used in a wide range of grazing systems but is only suited to soils with good drainage as it has poor water-logging tolerance. It has the advantage of also producing feed during the winter months although the amount produced depends on the variety grown and soil moisture available. Bloat can be a significant issue particularly when no other feed is available. Lucerne will persist for 3–5 years but only in fertile, well drained soils such as alluvial loams and so is only suited to a limited area of the Fitzroy River catchment.

Medics (*Medicago* spp.)

Medics are winter-growing, annual forage legumes that are highly productive in years when April to August rainfall is above 200 mm. Typically tropical grasses have extracted available soil water by autumn, and in spring, heat significantly lowers medic seed set and subsequent regeneration potential. Hence medics are not relevant in the northern Fitzroy River catchment and unreliable in the southern Fitzroy River catchment due to low and infrequent winter rainfall and short winter seasons. In southern Queensland medics play a significant role in providing quality winter feed as they can persist on the clay soils in this area and they are more adapted to this climate with cooler and longer winters and higher rainfall. Barrel medics are more productive than snail medics under lower rainfall conditions but are not as productive in the wetter seasons. Burr medics which have naturalised throughout southern Queensland play an important role in the wetter winters. Overall, medics can provide useful feed at a time when perennial grasses are dormant and of low quality, however are not reliable in the Fitzroy River catchment area.

Annual forage mixes

Sowing a cereal forage and legume mix can in theory provide a more balanced diet for cattle resulting in less wastage of protein. However, in reality, forage mixes are problematic as they are difficult to manage for optimum grazing time and duration of all the forage species in the mix. In-crop weed control is also a problem.

Forage sorghum and lablab

Mixing forage sorghum and lablab has been a relatively common commercial practice with the objective being to provide a more balanced diet, and for lablab to contribute nitrogen for growth of the forage sorghum. In practice, cattle preferentially select one species over the other. This lowers the productivity of both species, as one species can be overgrazed whilst the other is initially underutilised and then consumed at a later stage, possibly past its prime. In addition, nitrogen contribution from legumes mainly occurs after leaf fall and plant death. Therefore the nitrogen benefit is only realised once plant material is incorporated into the soil and decomposed by microbes, releasing the nitrogen some months later after the crop has finished.

Oats and medics

Mixing oats and medics is practiced for the same reasons as mixing forage sorghum and lablab—to improve the quality of feed available. In this case, there is relatively little advantage of mixing the two species together as oats can provide high quality forage (high digestibility and protein) on its own. In addition, in central Queensland where winter rainfall is unreliable, the forage production of each species is rarely maximised.

Ley pasture mixes: perennial, legume–grass pastures

Pasture mixes used in a ley system (pasture phase in a crop rotation) can produce high quality forage material and thus result in high animal performance. They also provide soil health benefits with improved organic carbon and nitrogen supply as well as soil structure improvements. To obtain the full benefit from the ley pasture it is essential that a productive grass and legume are grown together. Without a companion grass to drive nitrogen fixation, the legume will initially use available soil nitrogen and later only fix enough nitrogen for its own needs, having little impact on soil nitrogen or organic carbon levels. Adequate soil fertility, particularly phosphorus nutrition, is required to maximise legume growth and nitrogen fixation. Therefore to prevent production from the ley-pasture being significantly restricted, the key is to either not deplete soil nutrient reserves too much during the cropping phase, or ensure that adequate fertiliser is applied when the pasture is planted.

Expected forage yield

The quantity of forage produced will depend on the fertility and water holding capacity of the soil, the amount and distribution of rainfall received, any temperature limitations to growth, and managerial practices.

The average and range of forage biomass measurements made on commercial properties across the Fitzroy River catchment during the period 2011–2014 is presented in Tables 5 and 6. This data is presented in more detail in Chapter 9.

Table 5. Total forage growth (kg DM/ha) for annual crops monitored on commercial properties across the Fitzroy River catchment over the period 2011–2013[A]

	Oats	Forage sorghum	Lablab
Average (and range), across sites, of total forage biomass grown during the grazing period (kg DM/ha)	8184 (4939–16 456)	19 307 (9573–35 598)	9637 (5021–14 253)

A These figures are the maximum biomass measured in fenced (non-grazed) exclosure sites and are an indication of the total biomass grown in the paddock during the grazing period.

Table 6. Forage biomass (kg DM/ha) measured at perennial forage sites on commercial properties across the Fitzroy River catchment over the period 2011–2014[A]

	Leucaena–grass	Butterfly pea–grass	Perennial grass
Average (and range), across sites, of forage biomass measurements during grazing period (kg DM/ha)	Leucaena: 417 (196–744) Grass: 3809 (2700–5620)	Butterfly pea: 528 (143–1138) Grass: 4591 (3480–5519)	3702 (2186–4549)

A These figures are the average biomass measured in the grazed paddock over the duration of monitoring. They do not indicate the total biomass grown during that period due to being the net result of what was grown and what was consumed by grazing livestock. Figures for leucaena biomass represent only the edible material (i.e. leaves and stems up to 5 mm in diameter).

The frequency of suitable planting conditions for forages must be considered when estimating long-term potential forage yields. Examples of the percentage of years with conditions suitable for sowing annual forage crops are shown in Table 7 for three sites across the Fitzroy River catchment, representing the Central Queensland Open Downs (Emerald–Capella area), Central Queensland Brigalow (Biloela–Rolleston area), and South Queensland Brigalow (Taroom–Wandoan area) regions. These figures were derived from the plant production model, APSIM (Agricultural Production Systems Simulator) and were based on regional soil characteristics, and 108 years of historical climate data.

Table 7. Percentage of years with suitable conditions for sowing annual forage crops in the Fitzroy River catchment

% of years with suitable conditions for sowing	Oats	Forage sorghum	Lablab
Central Queensland Open Downs (Emerald-Capella area)	62	100	93
Central Queensland Brigalow (Biloela-Rolleston area)	67	100	100
South Queensland Brigalow (Taroom–Wandoan area)	67	100	100

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6 Cattle management and performance

Feed utilisation

Grazing cattle do not consume all of the forage dry matter produced. Under normal grazing conditions about 50% of total forage crop yield can be lost due to trampling and soiling. A general recommendation is to utilise only about 20–30% of the total forage yield of perennial pastures such as buffel or butterfly pea–grass pasture to ensure long-term sustainability. A greater proportion of an annual forage crop (oats, forage sorghum and lablab) can be utilised if the plants are not required to persist into another season. Grazing strategies such as strip-grazing and green-lotting can increase utilisation rates. These more intensive feeding systems force animals to eat more of the lower quality plant material—stems and old leaves—than they would otherwise select, resulting in lower liveweight gain.

Annual forage crops, particularly forage sorghum, can be under-utilised if the grazing pressure is too light. In this situation the crop matures rapidly and produces thick stems and seed heads resulting in a decline in feed value and poor utilisation. Using a high stocking rate and grazing early in crop development (first grazing when the plants are 1 m high) are strategies that can maintain crops in the higher quality vegetative state for as long as possible.

Feed quality and cattle intake

Both the quality and quantity of feed that the grazing animal consumes determines individual cattle growth rates. The quality and quantity of feed are related and are influenced by:

- soil or land type
- fertiliser application
- pre-planting and in-crop rainfall
- age of the pasture or forage
- plant species and cultivar type making up the feed-base.

Feed quality

A major indicator of feed quality is the digestibility or energy content of the feed. Dry matter digestibility (DMD) is the proportion of the feed that an animal digests in the stomachs, taking into account losses due to material excreted in the faeces. Metabolisable energy (ME) is the energy left after losses in faeces, urine and methane gas are subtracted. Feed quality values are often expressed as DMD, whereas the energy requirements of cattle for maintenance and growth are often expressed in terms of MJ ME/kg.

The digestibility of a forage is related to the proportion of cell wall material—fibre and silica—in the plant. Tropical forages generally have higher fibre and silica contents, and are therefore less digestible, than temperate species of the same age. Mature grasses are generally less digestible than mature legumes. The proportion of less digestible cell wall material increases as plants age. This is associated, in part, with a decline in the leaf to stem ratio within the plant. The nitrogen content of plants also declines with age.

Protein and mineral levels must be adequate for optimal cattle growth to occur for the given level of energy intake. Generally, when high quality forages are being grazed, the high amount of available green leaf usually means the protein and mineral concentrations in the feed will be adequate for growth. This means that energy will be the primary limiting factor.

It is important to recognise that the concentration of nutrients in the diet that grazing cattle select is not the same as that in the entire plant. This is because cattle preferentially graze plant species, and plant parts, and will select a diet higher in quality than the average of the total material on offer.

There is a wide range of possible nutrient values for a particular forage or pasture type, depending on the mix of species, cultivar, soil type, fertiliser application, age of pasture and the amount of selection that cattle are allowed. Selection is directly related to the stocking rate. Table 8 gives an example of the concentrations of energy and protein that can be expected in the highest quality component of the plant—the green, growing leaf material—of some common forage types. It is important to remember that the animals will also select a significant proportion of stem material, depending on the stocking rate, so the nutritive value of the diet will usually be less than the optimum that green leaf material can provide. These values are based on the assumption that soil nitrogen is not limiting for annual crops.

Table 8. Examples of energy and protein concentrations in green leaf material of major forage and pasture types, as compared with sorghum grain and a protein meal

Forage	Dry matter digestibility (%)	Metabolisable energy (MJ/kg DM)	Crude protein (% DM)
Sorghum grain[A]	77	12.1	10
Cottonseed meal	72	11.3	51
Buffel on brigalow soils, early wet season	60	8.0	17
Oats	80	12.1	32
Forage sorghum	65	9.5	18
Lablab (annual species)	70	10.2	25
Butterfly pea[B]	68	9.8	24
Leucaena[B]	60	8.7	23

A Values represent the feeding value of dry rolled sorghum grain. There can be extreme variability in sorghum grain quality with different varieties.

B Values represent edible material (i.e. leaves and stems up to 5 mm in diameter for leucaena).

Feed intake

Predicting the amount of feed that animals will consume is a complex task and there are a number of equations provided in the Australian ruminant feeding standards (CSIRO 2007) that can be used for this purpose. However, the existing equations do not provide accurate predictions for intake of tropical forage diets. A rough guide is that an animal should consume between 1.5–3% of its body weight as forage DM daily, when forage is of high quality.

The amount of feed that an individual animal consumes is affected by the interaction of the following factors.

a) Total amount of forage dry matter (DM) on offer

Feed intake can be reduced if the amount of feed on offer (biomass) is low. Forage biomass is usually expressed as kg DM/hectare.

b) Bulk density of the forage

Bulk density of a forage is the weight of forage material per area occupied. Low bulk density can constrain the ability of the animals to harvest the forage and so limit intake. The bulk density of tropical grass and legume pastures can be less than that of annual forage crops. In particular, in some situations the bulk density of leucaena leaf in leucaena–grass pastures may limit intake.

c) Feed quality

The higher the nutritive value of a feed (high digestibility and protein) the higher feed intake will be. The effect of feed digestibility on intake is largely due to the rate of passage of the forage material through the rumen. The more quickly feed is digested, the more quickly it passes through the rumen, allowing the beast to consume more feed.

d) Palatability of the forage

The higher the palatability of feed on offer the higher intake will be. The palatability of forage components and species influences how strongly animals will select for it within a pasture sward and can affect the intake of individual forage species within a mixed sward as well as total intake in a pure forage sward. For example, some studies show that cattle do not accept lablab well when they are first introduced to the forage. This can result in reduced forage intake, and thus low growth rates, for the first 2–3 weeks of grazing. One strategy to circumvent this problem is to provide access to an adjacent area of grass pasture or another forage source during the early grazing period while cattle are adjusting to the lablab forage. Alternatively, it is possible that cattle may compensate for this low intake in the subsequent weeks of grazing. In another example, the high palatability of the pasture legume burgundy bean causes cattle to heavily select it when growing with grass in a mixed sward. Thus, intakes of legume will be high initially, but will decline over time as burgundy bean is preferentially grazed out of the pasture and replaced with the grass species.

e) Grazing time

The amount of time spent grazing (hours per day) will determine the amount of feed that can be consumed. Generally animals will eat until they are "full". Environmental factors such as rain, wind and temperature can influence grazing time. Animals can increase the time spent grazing in an attempt to meet their daily feed intake requirements if the amount of feed on offer, or the bulk density of feed, is low.

f) The amount and quality of any feed supplements

Energy, protein and mineral supplements such as grain, protein meals or mineral mixes, may have different effects on the intake of forage, depending on the quality of the base forage diet and the amount of supplement consumed. For example, providing a grain-based concentrate at moderate to high intake reduces forage intake as the animal substitutes grain for some of the paddock feed. However, even when substitution occurs, the total digestible dry matter intake of the animal is normally increased so animal growth is also increased.

g) Anti-nutritive substances or toxins

Anti-nutritive substances or toxins may be present in some pasture plants or associated weeds and can depress intake. Under certain conditions, such as when hungry or stressed, animals gorge on toxic plant species and these toxins can cause illness and death. Examples of anti-nutritive substances include:

- inorganic compounds and minerals such as nitrate, found in lush forages when soil nitrate levels are high and conditions are not suitable for plant growth (e.g. frost, drought)
- organic compounds such as tannins and alkaloids (e.g. mimosine found in leucaena and prussic acid produced in stressed forage sorghum crops)
- fungal or bacterial toxins (e.g. ergot infections in forage sorghum seed-heads).

h) Animal liveweight, age and physiological state

Older, heavier cattle and gestating or lactating animals consume more feed per beast than younger, lighter stock and thus require a greater grazing area.

i) Previous nutritional and growth history

If cattle undergo a period of severe nutritional restriction, an effect known as compensatory gain can occur once cattle are provided with better nutrition. This results in greater-than-expected weight gains. It is believed that compensatory growth is primarily a result of increased feed intake, which can be 15–30% higher than what would normally be expected. The length and severity of the period of low nutrition, and the quality of the high nutrition feed, will affect the rate of compensation.

j) Water quality

It is important to ensure that water sources are clean, free of organic contamination and not too saline (less than 1000 ppm total dissolved solids is desirable). Poor water quality reduces water intake which, in turn, reduces feed intake.

Energy requirements for growth and feed conversion efficiency

Energy intake drives cattle production and growth. The more energy consumed, the greater the animal's growth rate. Protein and mineral levels are also important, but often their effect is through increasing the energy intake of the animal.

The total metabolisable energy intake of cattle is determined as the forage intake (kg DM) multiplied by its energy content (MJ ME/kg DM). Therefore, a forage with higher energy density has a double effect in increasing energy intake as the greater digestibility means cattle can also physically consume more of the forage.

The metabolisable energy intake in excess of that required for maintenance of the animal can be used for growth. Type, breed or genotype, class, size, physiological state (e.g. growing, gestating or lactating) and age of the animal, as well as environmental stresses such as temperature and activity levels all influence nutritional requirements for maintenance and production. For example, *Bos indicus* cattle breeds have a lower maintenance energy requirement than *Bos taurus* breeds. Another example is: the greater the distance animals have to walk to obtain feed and water, the greater the energy expenditure, reducing the remaining energy available for growth.

A complex interaction of factors affects the efficiency of converting feed energy into weight gain. One factor is the stage of maturity of cattle and the associated changes in the composition of the weight gain. For instance, as cattle increase in age and body weight the ratio of fat to protein increases in each kg of weight gain, decreasing the feed conversion efficiency. For example, older cattle may require 10–12 kg of feed DM per kg of liveweight gain compared to 7–10 kg per kg of liveweight gain for younger stock. In addition, the utilisation of energy in the diet for production becomes more efficient as the metabolisable energy concentration of the feed increases.

A series of equations can be used to predict the metabolisable energy requirements for maintenance and production of cattle under specific situations. These equations are found in feeding standards such as the Australian ruminant feedings standards (CSIRO 2007).

Indicative weight gains on forages

Table 9 provides a general indication of expected animal production for high quality forages in the Fitzroy River catchment. These values may vary due to soil type and nutritive levels. Due to higher digestibility, winter forages such as oats can support the highest daily liveweight gains of all forage options over their 'normal' grazing periods. Forage sorghum is capable of supporting very high stocking rates and correspondingly the highest beef production in kg/ha/year of all forage options. Combining a perennial legume with a grass pasture provides a system which can support stocking rates, grazing days, daily gains and total beef production per hectare, intermediate between grass-only pasture and annual fodder crops. Legumes, as pure stands or with grass, have the capacity to increase daily liveweight gain above that expected from tropical grass species largely due to increasing the digestibility of the diet.

Comparing animal production data from forage systems is an initial step in evaluating forage options. It is important to also assess the economic outcome of utilising a particular forage option. In addition, an assessment of environmental and managerial factors is of critical importance in the decision-making process.

Table 9. Indicative production figures for finishing cattle grazing dryland forages in the Fitzroy River catchment[A]

Forage	Feeding period[B]	Grazing days (days/year)	Daily gain[C] (kg/head)	Stocking rate (AE/ha)[D]	Beef production (kg/head/year)	Beef production (kg/ha/year)[D]
Grass-only pasture						
Buffel–brigalow soils	Annual	365	0.46	0.33	168	57
	Summer	90	0.84		76	
	Autumn	92	0.38		35	
	Winter	92	0.24		22	
	Spring	91	0.38		35	
Queensland bluegrass–open downs soils	Annual	365	0.39	0.17	142	25
	Summer	90	0.77		69	
	Autumn	92	0.34		31	
	Winter	92	0.11		10	
	Spring	91	0.34		31	
Perennial legume + grass						
Butterfly pea–grass	Oct–May	250	0.6	0.8	150	108
Leucaena–grass	Sept–May	270	0.9	0.6	243	140
Summer fodder crops						
Forage sorghum (delayed flowering variety, e.g. Sweet Jumbo LPA)	Feb–May	120	0.6	3.0	72	183
Lablab (annual spp.)	Dec–May	100	0.8	2.5	80	171
Winter fodder crops						
Oats	Jun–Nov	83	1.1	2.0	91	157

A These estimates are based on an assessment of the available measured values and the considered judgement of DAF beef research and extension staff. The values are based on the assumption that forages have been grown and grazed using best-practice agronomic management and represent the expected long-term average performance over both good and bad rainfall years for forages grown on brigalow soils in central Queensland.

B Summer: December–February, Autumn: March–May, Winter: June–August, Spring: September–November.

C Growth rates estimated for HGP-free cattle.

D AE (adult equivalent) = 450 kg non-lactating beast, calculated as liveweight to the power of 0.75. Stocking rates for high quality forages are those required to finish cattle. The stocking rates presented here are for the period of grazing rather than over 365 days. The total beef production has been determined assuming steers are finished to 310 kg carcass weight. Only the area of sown forage has been considered in stocking rate and beef production/ha calculations (i.e. additional areas of grass access that may be provided in association with fodder crops are not included). The beef production has been calculated using a stocking rate of actual animals/ha determined from stocking rate in AE/ha, at the liveweight of steers at the half-way point of the finishing period.

Compensatory growth

Compensatory growth is the greater-than-expected weight gain in animals following an extended period of slow growth or weight loss due to restricted nutrition. For example, cattle not supplemented during the winter will often grow at a faster rate during the following summer than similar cattle that received winter supplements (Figure 3).

The degree of compensatory growth is variable, ranging from zero to 100% depending on the:

- length and severity of the period of poor nutrition
- level and duration of improved nutrition following the period of poor nutrition
- age of the animals.

Generally, the more severe the reduction in growth rate (or weight loss) and the better the nutrition offered afterwards, the greater the extent of compensation.

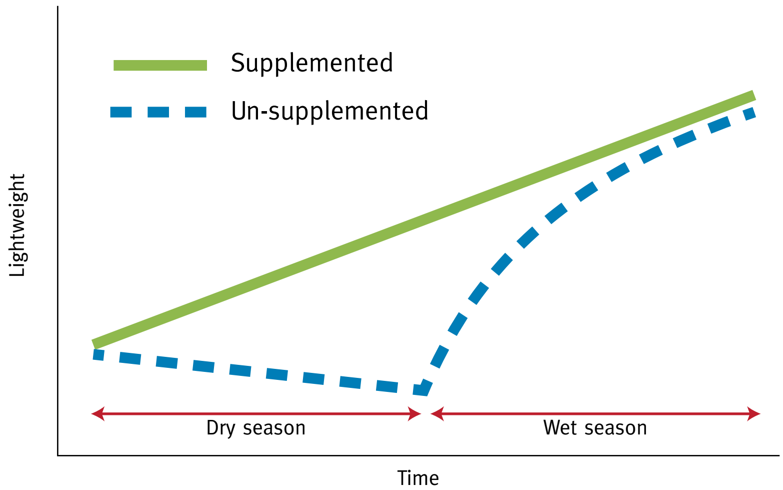

Figure 3. Liveweight of supplemented and un-supplemented cattle over time, showing compensatory gain, or 'catch-up growth', of the un-supplemented cattle during the subsequent period of better quality, wet-season, pasture. (S McLennan, unpublished)

It is believed that compensatory growth is primarily a result of increased feed intake, typically 15–30% higher than what would normally be expected. The mechanisms behind compensatory growth are not fully understood, making it difficult to accurately predict growth rates of cattle exhibiting compensatory growth effects.

The implication of the compensatory growth effect is that cattle should be sold straight off high quality forage, unless going on to another high quality forage. If animals are carried over for another season after feeding, the liveweight advantage gained through feeding on high quality forage could be eroded to some extent by compensatory growth. That is, the liveweight advantage of the cattle a season later will be less than it was just after the forage feeding was completed relative to similar cattle that did not graze improved forage, with obvious negative effects on the cost efficacy of forage feeding.

Strategies that may help prevent cattle being carried over for another season after grazing high quality forages include:

- stratifying the cattle into groups based on weight and condition and then targeting feed to those that will have a good chance of meeting the target market specifications
- adjusting stocking rates on the forage to ensure adequate liveweight gain to reach the target finishing weight
- providing grain supplements to increase grazing time on the forage and increase energy intake and growth rate.

Growth promotants

Hormonal growth promotants (HGPs) can increase growth rates of cattle by 10–30% and feed conversion efficiency by 5–15%. The increased growth rates can have a significant benefit, enabling the weight-for-age specifications of the target market to be met, particularly when cattle are grazing perennial grass-only pastures. Cattle need to be gaining weight to receive the maximal response from HGPs. The more frequently cattle are treated with a new implant the greater the overall response in liveweight gain. Once an implant program has commenced, it should continue through until slaughter to maximise the growth response.

Cattle treated with HGPs are excluded from the European Union and PCAS markets. In addition, HGP treatment can make it more difficult to achieve the MSA grading specifications required to achieve maximum price per kg carcass weight. Cattle treated with HGPs will receive a lower MSA grading score, due to a penalty in the MSA grading system for HGP treatment as well as the higher ossification score that HGP treated cattle have.

HGPs can also increase carcass leanness by 5–8%. Thus, HGPs may not be beneficial when late maturing genotypes are used to produce beef for markets requiring substantial fat levels at light carcass weights.

Animal health considerations

Good animal husbandry and management is required to decrease the risk of non-nutritional or health factors having a negative effect on growth rates of animals grazing high quality forages. The risk and incidence of the majority of the diseases listed below are minor but it is important to be aware of the potential for these diseases to occur and to take preventative measures where appropriate.

Bovine ephemeral fever (three-day sickness)

Mosquitoes and sandflies spread the arbovirus that causes bovine ephemeral fever, commonly known as three-day sickness. This disease has a relatively high occurrence in central Queensland. The symptoms include fever, shivering, lameness and muscular stiffness, and in extreme cases death. Cattle can take from one day to several weeks to recover, severely reducing growth rates during this period. Fat cattle are more severely affected than cattle in store condition. Vaccination is the only means of prevention with two vaccinations, 2–4 weeks apart, then an annual booster to maintain protection. Outbreaks of three-day sickness can occur at any time of the year but are more common in summer. Timing the annual booster for August is recommended to boost protection prior to the increase in insect numbers.

Enterotoxaemia (pulpy kidney)

The prevalence of enterotoxaemia, or pulpy kidney, in central Queensland is low, but the risk is there if rapid changes in feed quality occur.

The bacteria *Clostridium perfringens* type D which causes pulpy kidney lives in the intestines of normal, healthy cattle. However, sudden changes in feed quality or digestibility, which occur when cattle are introduced to highly digestible feed after grazing low quality roughage, can produce conditions in the intestine that allows the bacteria to proliferate. Such highly digestible forages include very lush forage oats, ryegrass and pastures containing medics and clover. The bacteria produce a toxin that can cause convulsions and death. Adult cattle may develop severe bloat before dying.

There are no effective means of treating the disease. Prevention is through use of a vaccine protective against the bacteria in question, such as 5-in-1 and 7-in-1. After the initial course of two vaccinations, given 4–6 weeks apart, an annual booster dose should be given to coincide with the animals going on to high quality forage. Timing the annual booster so it is given just prior to introducing cattle to the forage is particularly important because the protection the vaccine provides may only be as short as three months.

Other clostridial diseases such as blackleg can be stimulated to occur under high quality forage feeding conditions and can be fatal. Most losses occur in cattle less than two years of age although losses can occasionally be seen in older cattle. As for enterotoxaemia, vaccination with a multivalent vaccine (5-in-1 or 7-in-1) is the only effective means of controlling other clostridial diseases, with the exception of botulism, which requires a separate vaccine.

Botulism

Ingestion of the toxin that the bacteria *Clostridum botulinum* produces causes the fatal disease, botulism. Stock are at risk of botulism when they suffer from protein and phosphorus deficiency because this may cause them to chew bones and decaying material that may carry the bacterium. Additionally, accidental cases can occur when feed contaminated with rodent, bird or reptile carcasses is fed out or if carcasses contaminate the water source.

Generally, under conditions of high quality forage production on better quality soils in central Queensland, cattle should not be protein and phosphorus deficient. However, give consideration to botulism risks if the cattle have been backgrounded on phosphorus deficient country prior to introduction to the higher quality forage, or if the forage has been sown on soils marginally deficient in phosphorous.

There are two types of vaccine available to prevent botulism. One type requires an annual booster and the other gives protection for up to three years.

Mimosine toxicity when grazing leucaena

The toxic amino acid, mimosine, is found in the leaves, green pods and seeds of leucaena. The highest concentrations are found in fresh new growth. Mimosine is rapidly broken down in the rumen to a secondary product called dihydroxypyridine (DHP). DHP is also toxic. It can affect the normal functioning of the thyroid gland and thereby ultimately reduce cattle weight gains. The effects are cumulative, meaning that animals grazing large amounts of leucaena over longer time periods will have a greater likelihood of developing signs of toxicity. Mild cases of DHP toxicity cause depressed intakes and reduced growth rates. More severe cases of mimosine and/or DHP toxicity result in hair loss (primarily from the brush of the tail, the pizzle and the poll of the head), lethargy, sores on the skin, excessive salivation, goitre, abortion and death.

The effects of toxicity can be prevented by introducing a bacterium into the rumen of cattle which is capable of degrading DHP to a non-toxic compound. A commercially available bacterial inoculum is produced by DAF and distributed from the Tick Fever Centre at Wacol, Brisbane. Orders can be lodged by calling (07) 3898 9655.

The recommendations for inoculation are:

- graze cattle on leucaena for around 10–14 days prior to drenching to ensure mimosine and DHP levels in the rumen are sufficient to ensure survival of the bacterium
- drench 10% of the mob with 100 mL of inoculant/beast. The bacterium will spread to the rest of the individuals within the mob within 5–6 weeks by contact with the treated animals. Do not use any other method to introduce the bacterium solution into cattle. The bacterium is anaerobic (cannot live in the presence of oxygen) and is also susceptible to sunlight. Therefore, for example, attempting to administer the inoculant via water troughs or dams will kill the bacterium
- to prevent the requirement for drenching new animals each time a mob is introduced to leucaena, some previously exposed animals can be carried over and allowed to run with the new mob for 4–6 weeks.

Prussic acid poisoning from sorghum

Under certain conditions, forage sorghum crops can produce dangerous amounts of prussic acid (cyanide). The risk is highest when drought, frost, trampling or other damage such as insect or hail damage has affected growth of the crop. The risk is accentuated on water-stressed corps during cloudy/overcast condition as the prussic acid mobilise from roots to leaves. Prussic acid prevents oxygen reaching the animal's tissues. Toxicity causes decreased feed intake, milk production and growth rates, and in severe cases cause death. Symptoms of acute poisoning include rapid, heavy breathing, frothing at the mouth, muscular twitching, convulsions, staggering and coma. Most acutely affected animals die quickly, within 15–20 minutes after consuming the forage.

All sorghums have the potential to induce prussic acid poisoning. However, grain sorghums, sweet forage sorghum and delayed-flowering varieties have a much higher cyanide potential than other varieties. The toxin can be present in dangerous amounts at any growth stage of the crop, with the least risk of cyanide in flowering or seeding plants. Cyanide concentrations above 600 ppm are generally considered hazardous but levels as low as 200 ppm can be dangerous for very hungry animals in a drought.

In practice, the number of deaths due to prussic acid poisoning is very small compared to the number of animals grazing forage sorghums. The following guidelines can minimise the risks of toxicity:

- avoid grazing stressed young sorghum plants or stressed regrowth
- delay grazing until plants are over 45 cm for shorter varieties or over 75 cm for tall varieties
- do not put hungry stock onto sorghum crops, particularly if the crop is wilted or stressed
- watch stock for the first hour of grazing and then check on them regularly for the first few days
- supplement stock on sorghum crops with sulphur (e.g. 10% sulphur in a salt lick). Sorghums are generally low in sulphur but sulphur is required for detoxifying cyanide in the rumen and liver
- test any hay and silage made from sorghums considered high-risk prior to feeding out
- keep a supply of sodium thiosulphate on hand for emergency treatment of cyanide poisoning. If any cattle show signs of toxicity or death, drench all cattle immediately with 60 g of sodium thiosulphate in 600 mL of water. Repeat this drench hourly until the animal recovers. Alternatively, a veterinarian can administer the more effective intravenous injection of sodium thiosulphate.

Ergot poisoning from sorghum

Sorghum ergot is caused by a fungus, *Claviceps africana*. Ergot infects sorghum plants during flowering, particularly in cold weather, with a fungal body (sclerote) replacing the ovaries of infected panicles (flowering heads). Sclerotes of *C. africana* contain toxic chemicals, in particular the alkaloid dihydroergosine (DHES) which have caused hyperthermia (or overheating) and reduced growth rates in cattle fed diets containing 1–2 mg DHES/kg.

Little is known about the effect of ergot on livestock grazing infected forage sorghum. The dose ingested by grazing cattle is dependent on the degree of ergot infection and development in the panicles, dilution with other plant material and animal selection. The risk will be higher if cattle preferentially select infected grain heads. Watch cattle grazing on infected forage sorghum crops closely for signs of ergot poisoning. Symptoms include signs of overheating such as excessive salivation, seeking shade and standing in water. Move affected stock quietly onto alternative feed during a cool time of day.

Preferentially, graze or cut forage sorghum for silage before flowering, particularly in late summer and early autumn when the risk of ergot infection is highest. In crops that have flowered less than three weeks previously, the amount of DHES consumed by grazing cattle should be below the level that adversely affects weight gain. Ensilation of forage sorghum in the early stages of ergot infection (prior to sclerote formation) further reduces the risk. Trials have showed that alkaloid levels in silage containing ergot-infected seed heads were reduced by about 50% after six weeks.

Nitrate and nitrite poisoning

Under conditions of high soil nitrate levels and slow growth, forage crops can accumulate high levels of nitrates. Forage sorghum, grain sorghum, sudan grass, sudan grass hybrids, pearl millet and forage oats are well-recognised nitrate accumulators. Rumen microbes break down nitrate to form nitrite which is much more toxic than nitrate, reducing transfer of oxygen to the tissue and causing sudden death in severe cases. Symptoms include increased rate and depth of respiration, muscular twitching, staggering, collapse, convulsions and coma. Acutely affected animals develop a bluish tinge in their eyes and lips and have a weak, rapid pulse. The blood is typically dark brown.

Plants with more than 1.5% potassium nitrite on a dry matter basis are potentially dangerous to hungry stock. Animals can acclimatise to large concentrations of nitrate if introduced to the forage gradually. However, any sudden increase in feed intake or the feeding of supplements containing monensin can lead to poisoning due to changing the rumen bacteria's capacity to degrade the nitrate.

Poisoned animals found alive can be saved. Intravenous injection of methylene blue, at a dose rate of 2 mg/kg at a concentration of 2–4% in water (20 g in a litre) can prevent and treat nitrate poisoning. It is best if a veterinarian administers the injection.

The following strategies will reduce the risk of nitrate and nitrite poisoning:

- analyse feeds and forages for nitrate concentrations prior to grazing
- feed hungry stock on dry roughage or mature grass before providing free-access to potentially risky feed
- prevent hungry stock from grazing recently sprayed weeds
- prevent hungry stock from gorging on highly fertilised crops
- moderate the stocking rate on high-risk crops to minimise the amount of stem consumed because the stem contains the highest concentrations of nitrate
- observe stock frequently after they are introduced to potentially high-risk feeds
- do not graze high-nitrate crops for seven days after periods of rainfall, cloudy days, frosts or high temperatures that cause wilting
- graze stock on high-nitrate crops during sunny afternoons and remove them at night when nitrate levels accumulate
- harvest forages containing high-nitrate levels and feed as silage because the fermentation process during ensilage reduces the nitrate levels.

Hypomagnesaemia (oat tetany)

Hypomagnesaemia occurs mainly in adult cattle, especially cows in the first few months of lactation. It can occur when cattle are introduced to high quality forage with inherently low magnesium levels, such as oats, especially if they have been fertilised with nitrogen and phosphorus. Although low blood magnesium levels are always present, the disorder is complex involving interactions between magnesium, potassium, sodium and nitrogen. Convulsions and death can occur within a few hours. Less acute symptoms include agitation, muscle tremor, staggering, staring eyes and frothing at the mouth.

The threat of hypomagnesaemia can be reduced by providing cattle on highly digestible forages, such as oats, access to grass pastures and by feeding magnesium supplements. Treat affected animals with subcutaneous injections of calcium and magnesium.

Internal parasites

Cattle under two years of age can be susceptible to parasites, especially at times of stress such as weaning. As cattle are concentrated on forage crops this favours the build-up of internal parasites.

Symptoms of worm burden include:

- rough and dull coat
- loss in condition
- scouring
- sunken eyes
- pale eyes and lips
- bottle jaw (swelling under the jaw).

Use a worm test kit to assess the worm burden of young cattle prior to deciding whether to drench. Kits are available at rural services outlets and some veterinary practices. If high egg counts are detected drench cattle prior to introducing them into clean paddocks. Grazing management techniques such as rotational grazing can help prevent reinfestation from contaminated pastures.

Poisoning from dump sites and weeds

When lush forages form the sole diet, cattle may be attracted to different types of plants or to licking or ingesting materials that they would not normally consume. To minimise the risk of poisoning, and/or unacceptable chemical residue levels in the beef produced, fence off old dump sites, sheds or barns to prevent access. Producers should also be wary of the accessibility of poisonous weeds, such as lantana or poison peach, in the forage grazing area.

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Training courses:

The Queensland Department of Agriculture and Fisheries (DAF) delivers EDGEnetwork Workshops focused which are tailored to your local area. Workshops focussing on ruminant nutrition and grazing management strategies include the 'Nutrition EDGE' and 'Grazing Land Management' courses, respectively. Contact your local DAF beef extension officer (on 13 25 23) for more information or find more details at www.mla.com.au.

7 Gross margin analysis

Example gross margins are presented for three sites across the Fitzroy River catchment, representing the Central Queensland Open Downs (Emerald–Capella area), the Central Queensland Brigalow (Biloela–Rolleston area), and the South Queensland Brigalow (Taroom–Wandoan area).

The gross margins are provided as an example of the costs and returns that might be expected for six forages in different regions when used to finish steers. The sample spreadsheets provided with this guide contain the example gross margins but can also be used to test alternative scenarios based on individual property production and input figures. These spreadsheets can be downloaded from the DAF FutureBeef website at www.futurebeef.com.au.

The example gross margins given here allow a comparison of forages to be made but do not identify the economic value provided by forages to the farm business. Some of the factors that should be taken into consideration when assessing the economics of forages, as well as some of the environmental and managerial factors that need to be accounted for in the decision-making process, are outlined in Chapter 8.

General description of the gross margins

The gross margins are based on the following sites:

- Central Queensland Open Downs (Emerald–Capella area)
- Central Queensland Brigalow (Biloela–Rolleston area)
- South Queensland Brigalow (Taroom–Wandoan area).

Six forage types were modelled at each of the sites:

- the annual forages: oats, sorghum and lablab
- perennial legume-grass forage systems: butterfly pea–grass (i.e. a mixed sward of butterfly pea and grass) and leucaena–grass
- perennial grass pasture (as a baseline for comparison): Queensland bluegrass pasture for Central Queensland Open Downs and buffel grass for Central Queensland Brigalow and South Queensland Brigalow sites.

A description of each of these example sites and the general assumptions used in the analysis are detailed in Appendix 1. More detailed information, including unit costs, can be obtained from the spreadsheets. These scenarios were constructed prior to measurement of data on producer properties and some of the assumptions made do not reflect what was found to be common practice commercially (see Chapter 9). An example is the assumed proportion of perennial grass provided in conjunction with sown forage crops. Alternative assumptions and scenarios can be tested using the sample spreadsheets provided with this guide.

The growing costs of the forages were based on a mixture of chemical and mechanical, fallow weed control methods plus property ownership of the machinery used. This was done to match current industry practice.

Cattle production from each of the forage types was assessed by using a scenario where steers were finished to the same target weight: 596 kg liveweight (310 kg carcass weight). Cattle were assumed to enter the system at a starting weight sufficient to reach the target turn-off weight within the specified grazing period, and were valued at this entry weight. The grazing days, stocking rate and daily liveweight gain for each forage at each site were based on an assessment of measured values in both unpublished and published reports and the considered judgement of experienced beef research and extension staff. These values are based on the assumption that forages have been grown and grazed using best-practice agronomic management and represent the long-term average performance for a forage crop that is successfully planted.

No allowance has been made for the potential cropping frequency of the annual forages at any of the locations. Any comparison of the gross margins of annual and perennial forage crops should take into account the reliability of the various forages at the location under consideration. Representative data for climate, and the percentage of years on average with conditions suitable for sowing each of the forages, at the three sites are given in this guide in Chapters 3 and 5, respectively.

Gross margins

Agronomic, livestock production and market data were used to produce the expected gross margin results for each of the forage types. The gross margin for a forage scenario is equivalent to the gross income received from sale of cattle less the variable costs incurred. Variable costs include both cattle and forage costs, are directly attributable to an individual animal or production activity, and vary in proportion to the size of the activity. Examples of cattle costs include purchase, freight and animal health expenses. The forage costs were calculated as if plant and machinery were owned by the business with overhead costs excluded from the gross margin (i.e. owner rates).

There were assumed to be no variable costs associated with establishing or maintaining the existing perennial grass-only pastures, therefore the gross margin for perennial grass pastures was calculated based only on livestock costs and income. The gross margin values reported for the perennial grass pastures are annualised figures although the actual production cycle (from weaning to achieving finishing weights) is greater than one year. The annualised figures were used to allow comparison to the alternative forages that have varying production cycles.

All gross margins were calculated on the basis that steers were purchased at a sale yard and transported to the property.

Incorporating development costs

The costs of developing sown perennial legume-grass forages like leucaena and butterfly pea were amortised over the expected life of the forage. The estimate of development costs included an allowance for the potential grazing lost during the establishment period plus the interest cost of the working capital tied up in the development. The use of amortised (or average annual) development costs in the calculation of the gross margins enables comparison of the perennial forages with annual forages and perennial grass pastures. This comparison is a good starting point to make an initial short list of potential forages, but a range of other factors should also be taken into account. These include (i) the time taken and the high initial investment cost involved in developing perennial forages, (ii) the year to year variability of all forages, and (iii) how any forage fits into the chosen production and financial system.

Comparisons across regions

The objective of the economic analyses was to allow comparisons between forages within a region or site, not across the regions. As a result, some assumptions differ between sites. For example, compared to the central Queensland sites, cattle grazing the perennial grass pasture at the South Queensland Brigalow site were assumed to be one month older at weaning due to earlier mating in that region (see Appendix 1 for details).

Summary of results

Tables 10–12 show a summary of the gross margin results for all sown forages and the perennial grass pasture. All gross margins are presented on the basis of gross margin per hectare as land area is seen as the key constraint in this analysis. More detailed results for each of the three sites are shown on the sample spreadsheets for each region.

The key criterion for comparing the performance of the forages is the gross margin after interest as this figure makes an allowance for the value of the livestock capital tied up in grazing the forage. An interest rate of 5% was uniformly used to estimate the opportunity cost of livestock capital over the number of days grazing was undertaken.

The key assumed production figures are also presented for each forage type. Liveweight gain (kg/ha/annum) from forages and pastures was calculated using a stocking rate of actual animals/ha determined from stocking rate in AE/ha, at the liveweight of steers at the half-way point of the grazing period. AE (adult equivalents) = 450 kg, non-lactating animal, calculated as liveweight to the power of 0.75. All production and gross margin figures are expressed per the total grazing area, although it was assumed that oats and lablab forages were only planted to 90% of the paddock area. The figures presented for liveweight gain and grazing days for sown perennial forages represent the average production after the initial establishment phase. Stocking rates (AE/ha) were calculated for the duration of grazing for the annual crops but per annum for the perennial forages.

The results for Central Queensland Open Downs (Table 10) demonstrate that even though forage sorghum produces the greatest annual liveweight gain per hectare, it does not produce the greatest returns. This is due to the requirement to plant annually and the higher average forage growing costs when compared to the perennial legume–grass pastures. Leucaena–grass pasture produced the highest gross margin due to a high annual liveweight gain per hectare being achieved at the lowest average annual forage growing cost of the any of the sown forages.

Table 10. Central Queensland Open Downs: comparison of gross margin ($/ha/annum) and assumed cattle production for key forage options

	Oats[A]	Forage sorghum	Lablab[A]	Leucaena–grass	Butterfly pea–grass	Perennial grass pasture (native)
Livestock sales ($/ha/annum)	$1696	$2535	$1946	$553	$724	$58
Variable costs ($/ha/annum)						
Livestock purchases	$1349	$2039	$1559	$303	$493	$26
Freight in	$49	$81	$56	$13	$18	$1
Freight out	$60	$89	$69	$20	$26	$2
Treatment expenses	$1	$1	$1	$1	$0	$0
Selling expenses	$9	$13	$10	$3	$4	$0
Forage growing costs; owner rates	$180	$194	$153	$40	$58	$0
Total expenses	**$1647**	**$2417**	**$1847**	**$379**	**$598**	**$29**
Gross margin; owner rates	$49	$118	$99	$174	$126	$29
Gross margin (after interest); owner rates	**$35**	**$82**	**$77**	**$163**	**$110**	**$27**
Liveweight gain (kg/ha/annum)[B]	143	199	157	133	115	25
Stocking rate (AE/ha)[C]	2.0	3.0	2.3	0.44	0.59	0.17
Grazing days (days/annum)[B]	76	130	100	270	270	365

A Forage growing costs, gross margin and production figures are expressed per the total grazing area; oats and lablab crops were assumed to be planted to only 90% of the total grazing area with the remaining 10% being perennial grass pasture.
B Figures for liveweight gain and grazing days for sown perennials represent average production after the establishment phase.
C Stocking rates were calculated for the duration of grazing for the annual crops but per annum for the perennial forages.

The results for Central Queensland Brigalow (Table 11) show leucaena–grass pasture again produced the highest gross margin of all forage options. Of the annuals, forage sorghum produced the highest gross margin. All sown forage options produced significantly higher returns than the perennial grass pasture.

Table 11. Central Queensland Brigalow: comparison of gross margin ($/ha/annum) and assumed cattle production for key forage options

	Oats[A]	Forage sorghum	Lablab[A]	Leucaena–grass	Butterfly pea–grass	Perennial grass pasture (buffel)
Livestock sales ($/ha/annum)	$1535	$2525	$1946	$553	$711	$115
Variable costs ($/ha/annum)						
Livestock purchases	$1188	$2055	$1559	$303	$502	$51
Freight in	$35	$62	$48	$10	$15	$2
Freight out	$39	$64	$49	$14	$18	$3
Treatment expenses	$1	$1	$1	$1	$0	$0
Selling expenses	$8	$13	$10	$3	$4	$1
Forage growing costs; owner rates	$129	$138	$153	$42	$58	$0
Total expenses	**$1399**	**$2333**	**$1820**	**$373**	**$597**	**$57**
Gross margin; owner rates	$136	$193	$126	$180	$114	$59
Gross margin (after interest); owner rates	**$123**	**$159**	**$105**	**$169**	**$98**	**$56**
Liveweight gain (kg/ha/annum)[B]	141	183	157	133	97	57
Stocking rate (AE/ha)[C]	1.8	3.0	2.3	0.44	0.55	0.33
Grazing days (days/annum)[B]	83	120	100	270	250	365

A Forage growing costs, gross margin and production figures are expressed per the total grazing area; oats and lablab crops were assumed to be planted to only 90% of the total grazing area with the remaining 10% being perennial grass pasture.
B Figures for liveweight gain and grazing days for sown perennials represent average production after the establishment phase.
C Stocking rates were calculated for the duration of grazing for the annual crops but per annum for the perennial forages.

The results for South Queensland Brigalow (Table 12) show that the returns per hectare for leucaena–grass are about double the perennial grass pasture. Note that even though oats produced the greatest annual liveweight gains per hectare, it did not produce the greatest returns. This is due to the requirement to plant annually and the higher average forage growing costs when compared to the perennial legume–grass pastures. It must also be remembered that missed planting opportunities for oats are not incorporated in this analysis and also have to be allowed for. Compared to oats, forage sorghum produced greater livestock sales but resulted in a negative gross margin due to variable costs exceeding returns under the assumptions made in this scenario.

Table 12. South Queensland Brigalow: comparison of gross margin ($/ha/annum) and assumed cattle production for key forage options

	Oats[A]	Forage sorghum	Lablab[A]	Leucaena–grass	Butterfly pea–grass	Perennial grass pasture (buffel)
Livestock sales ($/ha/annum)	$1972	$2104	$1936	$496	$708	$115
Variable costs ($/ha/annum)						
Livestock purchases	$1581	$1781	$1637	$307	$533	$57
Freight in	$36	$38	$32	$6	$10	$1
Freight out	$80	$85	$78	$20	$29	$5
Treatment expenses	$1	$1	$1	$1	$0	$0
Selling expenses	$10	$11	$10	$3	$4	$1
Forage growing costs; owner rates	$160	$172	$153	$42	$58	$0
Total expenses	**$1867**	**$2087**	**$1910**	**$379**	**$633**	**$64**
Gross margin; owner rates	$105	$17	$26	$117	$75	$52
Gross margin (after interest); owner rates	**$85**	**–$14**	**$6**	**$107**	**$59**	**$49**
Liveweight gain (kg/ha/annum)[B]	197	152	141	106	92	53
Stocking rate (AE/ha)[C]	2.3	2.5	2.3	0.36	0.53	0.33
Grazing days (days/annum)[B]	90	130	90	240	240	365

A Forage growing costs, gross margin and production figures are expressed per the total grazing area; oats and lablab crops were assumed to be planted to only 90% of the total grazing area with the remaining 10% being perennial grass pasture.
B Figures for liveweight gain and grazing days for sown perennials represent average production after the establishment phase.
C Stocking rates were calculated for the duration of grazing for the annual crops but per annum for the perennial forages.

Best-bet forage options

The gross margin analyses based on the regional sites showed that a leucaena–grass pasture provided the highest gross margins when compared to other key perennial legume–grass and annual forage options. However, it is generally accepted that there is a lag time of 3–7 years after planting before the cash flow from leucaena–grass systems break-even when compared to the costs of establishment. This needs to be taken into account when long-lived perennial legumes are being considered.

The other perennial, legume–grass pasture examined in this study, butterfly pea–grass, also performed well in terms of gross margin, ranking second for the Central Queensland Open Downs site and third for the South Queensland Brigalow site. A useful life of 5 years was assumed in these scenarios for butterfly pea. However under conditions where butterfly pea is grown on good quality soils with optimal grazing management, butterfly pea may contribute to a more productive pasture for a longer period. This will correspondingly decrease annual, amortised forage costs and hence increase butterfly pea gross margins. In a mixed forage and grain cropping system the flexibility offered by butterfly pea, compared to leucaena, may add to its usefulness as it can be easily removed to allow the recommencement of annual grain cropping. However, its ability to deplete soil water and be a weed could potentially depress grain yields in the initial phase of the cropping cycle.

In the example scenarios for Central Queensland Brigalow and Central Queensland Open Downs sites forage sorghum produced the highest gross margins of the annual forages, and these were much greater than gross margins for the perennial grass pastures. However, forage sorghum produced a negative gross margin after interest for the South Queensland Brigalow site, in part due to the lower production expected in this region. The management of grazing is critical to achieving the estimated returns for forage sorghum at any location. It is also important to identify the price risk inherent in purchasing a large number of mature steers suitable to meet the optimal grazing needs of forage sorghum. A small change in the margin between the purchase price and selling price can dramatically impact on the profitability of the forage.

Oats and lablab produced higher gross margins than the perennial grass pasture in each region, except for lablab in South Queensland Brigalow.

Other than the cost of planting, other major factors that determine the relative profitability of forages are the cattle buying and selling price (price margin), the assumed daily cattle liveweight gain, the stocking rate and number of grazing days on the forage.

The results of any gross margin analysis are extremely sensitive to changes in the cattle price, and very sensitive to changes in cattle growth and in cost assumptions. At all three sites, growing annual forages had a relatively high risk of producing negative returns under some livestock sale price and liveweight gain combinations. The price risk associated with the relatively short periods of ownership of generally many more larger and older steers tied up in the use of annual forages tends to make such activities much more risky than the perennial grass pasture.

The results described in this report highlight the importance of considering gross margin performance, in addition to agronomic and livestock performance, when comparing forage options.

In this analysis only the scenario of finishing steers has been considered. Other uses of high quality forages include backgrounding or growing out steers prior to the finishing stage and providing high quality feed for special classes of cattle such as weaners or replacement heifers. Assessing the value added by forages in such circumstances is much more problematic than where the livestock are sold immediately for slaughter and the value added is captured. In particular, the influence of compensatory gains in offsetting the value added by feeding forages to young stock needs to be incorporated in any analysis of benefit.

There are some producers who use summer and winter forages, particularly forage sorghum, as part of a plan to either spell grass pastures, fill feed gaps or carry more cattle in total. The economic benefit of such strategies cannot be assessed by looking at the gross margins for the various pastures and forages involved. For these situations it is more appropriate to look at the impact on the profit of the whole farm business and consider the alternative operating systems available at that level.

Chapter 8 identifies some of the factors that need to be considered, and techniques available, when it comes to assessing the role of forages in the farm business.

8 Evaluation of economic, environmental and management factors

This chapter discusses the evaluation of economic, environmental and management factors that may influence decisions about whether to invest in high output forage systems.

Gross margins versus farm economic analysis

The gross margins presented in Chapter 7 compare the use of improved forages to perennial grass pasture. Such analyses consider only those costs and benefits directly related to the alternative activities and do not incorporate any indirect impacts on the farm business or the opportunity costs of investing in forage production.

Gross margins are most useful where an immediate, short-term comparison of alternative uses of a paddock is required. They do little to show the economic impact of forages on farm profit even though they are a useful starting point in collecting the data necessary to undertake an economic analysis.

The effect of forages on farm profitability requires consideration of a number of additional factors. For example, on a beef cattle property, improved carrying capacity and faster turnoff may increase the number of breeders required. Where grain crops are an option it may be possible to improve overall profitability by growing grain instead of forage. Additional overheads and significant changes to labour and machinery requirements may also need to be considered.

Therefore, if the effect of forages on overall profitability is to be assessed, forage gross margins need to be incorporated into a farm planning framework developed to measure profit. This is the only way the economic benefit of the forages can be identified.

A profit based farm planning framework

Making a change to production systems can have many effects on a farm business. The resources used, assets invested, gross income and farm costs can all change when a new, long-term target is selected for farm output.

When analysing such a change it is important to select a standardised approach that will rapidly measure any benefits and costs that may arise from the change. It is also important that the approach can account for the complexities that sometimes arise with farm change.

Profit budgets can screen the costs and benefits of farm change and generally incorporate the following steps:

1. Estimate farm output
2. Estimate variable costs
3. Estimate fixed costs
4. Calculate operating return

Profit budgets may not include some items normally found in cash flow budgets such as loan repayments, equipment purchases or personal drawings. These are not strictly production costs as required to formulate a profit budget and can be replaced by estimates of the economic costs of maintaining the capital of the farm and the costs of the paid and unpaid labour used in the production process.

Profit budgets can be constructed to account for the time taken to implement change so that the effect of delayed returns associated with some alternative production systems or development proposals can be considered. They can also be constructed to look at snapshots of alternative "futures" that may represent the average state of the farm business once the change has been implemented.

The consistent feature of a profit based farm planning framework is that the key measure is the expected impact on overall farm profit of implementing change, after all of the expected consequences of the change have been incorporated.

Profit budgets also allow consideration of the opportunity cost of the current farm plan, that is, the profit available from alternative uses of the farm resources.

Farm case studies to examine the economics of high output forages

As part of the MLA and DAF co-funded project, "High output forage systems for meeting beef markets – Phase 2", case studies were constructed with five beef producers across the Fitzroy River catchment who were currently extensively using forages in their production system. The results of the five case studies provide valuable insight into the profitability of high output forages as the co-operators were growing a wide range of annual and perennial forages.

At least two profit budgets were constructed for each co-operator with one considering the current forage system and its benefits and the other describing the performance of the most acceptable alternative system(s). The co-operator decided the alternative system(s) to be considered and described the expected performance of that system under their management. All of the property managers were considered to be competent and highly experienced in the productions systems that prevail in their region.

In most cases it was necessary to construct a herd model, a series of activity budgets to cover each alternative activity, and some estimate of the change in capital equipment and labour necessary to implement the potential change. Fixed or overhead costs incurred by the farm business that did not change were ignored.

The insights into the profitability of forages provided by the case studies can be summarised as follows:

- Under current market and cost conditions, perennial legume–grass pastures may have a significant economic advantage over annual forages.
- However, high-output perennial legume–grass forages may only add significant value to a beef enterprise where the growing of grain crops is not a realistic option.
- The effect of annual forages on farm profitability can be marginal and the increase in business risk significant, requiring a careful assessment of the role of annual forages in improving overall profitability.
- Where high-output annual forages are currently successfully grown and grain crops are a realistic option, it is most likely that grain crops will significantly outperform the alternative annual forage crop.
- Where grain crops are not an alternative and grass pasture is the alternative option under consideration, annual forages are a high cost option with high timeliness requirements that may only add value to the beef enterprise if the opportunity cost of plant and unpaid labour are excluded. Comparatively, perennial legume–grass forages may add value to the enterprise.

Even though annual forages generally produced better gross margins than perennial grass pastures at the paddock level, it appears that the inclusion of the costs not covered in the gross margin analysis in the farm level case study reduces the difference to the point where the additional expenses of annual forages were not covered by the additional income generated. Compared to perennial grass pastures, perennial legume–grass pastures improved farm profit even though their output of beef per hectare was usually less than if the same area was allocated to annual forages.

These insights reinforce the findings of previous work undertaken in this region over the past 10-15 years. That is, grain cropping is generally more profitable than grazed forages. If a successful forage crop can be grown then it is more than likely that a successful (and more profitable) grain crop can be grown in its place.

Where good quality cropping soils are available and grain cropping is not an option, it appears most likely that perennial legume-grass forages will add more profit to the farm business than annual forages.

Although these insights have proven to be robust over a number of case studies that does not mean they will hold true for all circumstances. It is still necessary for each manager, who is considering a change to their farm operations, to appropriately consider the impact on farm profit, risk and cash flow of implementing that change under their circumstances.

Considering management and environmental factors

The previous section highlights the importance of considering economic performance, in addition to forage and livestock performance, when comparing forage options. However, while the economic outcome of using a particular forage option is of critical importance to a beef business, environmental and management factors can also influence business decisions.

Although it is often difficult to quantify the impact of some of these factors, it is important to incorporate a qualitative evaluation of any additional benefits or constraints of the forage options, into any decision making. A summary of some of these additional factors that producers may wish to consider when making a decision about whether or not to incorporate an improved forage system into their business, are listed below.

Strengths/benefits	Constraints/threats
Perennial grass pasture (native and sown, grass-only pastures i.e. no change from status quo)	
• stable, robust and relatively reliable perennial pasture system • does not require any change of management or additional investment • does not have the climatic risk involved in taking land area out of production for planting to alternative forage options • simple beef management and marketing system • no requirement for specialised agronomic or managerial skills	• lower and more variable quality of feed than annual forage crops and perennial legume–grass pastures • lower stocking rates than annual forage crops and perennial grass–legume pastures • lower potential liveweight gain/head and gain/ha than annual forage crops and perennial legume–grass pastures • less flexibility in cattle marketing options and time of turn-off • limited potential to increase turnover and $/ha from the existing pasture base
Oats	
• produces high quality feed that fills a feed gap when the quality of grass-only pastures is low in winter and early spring • allows cattle to be finished and marketed out-of-season when demand and prices are likely to be higher	• unreliable autumn/winter rainfall, especially in the northern part of the Fitzroy River catchment, increases the risk that allocated land will be underutilised. For example, the years with suitable rainfall for sowing oats ranged from 67% at Taroom and Banana to 62% at Capella (based on modelling using historical rainfall records for the last 108 years) • at the end of the oats season, many cattle are often forced on to the market in a short time causing a market glut and temporary depression in market prices • requires annual planting • short grazing duration if sown on limited soil moisture or if there is low in-crop rainfall

Strengths/benefits	Constraints/threats
Forage sorghum	
• potential to fill feed gaps when the quality of grass-only pastures is low in early summer or early winter, for example: – fast growth can enable early summer grazing when planted with favourable soil conditions early in spring – sweet forage sorghum varieties can provide stand-over feed into winter • provides a large bulk of feed that can be used to reduce grazing pressure on the remainder of the property, allowing strategic spelling of pastures during the summer growing period or to allow feeding of additional, purchased cattle • the large bulk of lower quality feed produced (relative to other annual forage crops) is suited to backgrounding cattle prior to the finishing phase • can provide a long grazing season if planted early, receives adequate in-crop rainfall, and stocking rate is well managed	• difficult to manage for optimum quality and quantity: – the feed quality of sorghum rapidly declines as the crop matures. Using a high stocking rate and grazing early is a strategy to maintain feed quality for as long as possible by keeping the crop in the vegetative state. However, this can be a fairly high-risk strategy under dryland conditions when the in-crop rainfall may not be sufficient to maintain plant growth and the allocated cattle numbers through to finishing weights • cattle performance can be highly variable due to the difficulties in managing the forage for optimum quality • requires annual planting • if large numbers of stock are bought to enable effective grazing, economic risk increases due to the dramatic effect that a small change in cattle price margin can have on gross margin
Lablab	
• produces high quality feed that can fill a feed gap when the quality of grass-only pastures is low in autumn • easier to manage for optimum grazing quality (compared to forage sorghum) with more consistent quality throughout the grazing period • can reduce nitrogen fertiliser requirements in subsequent grain crop (when used as a short-term ley) or forage rotations (e.g. forage sorghum) • under careful grazing management, and if sufficient soil moisture is present, can potentially overwinter and provide valuable spring feed	• generally produces less quantity of feed compared to forage sorghum, and hence supports lower stocking rates • rarely persists for longer than one year and thus requires annual planting • forage quality markedly declines once frosted • grazing duration can be short if moisture is limiting or through poor grazing management
Leucaena–grass	
• produces high quality feed for most of the year which increases both animal performance and stocking rate compared to grass-only pastures • long-term perennial pasture system (>30 years) negating the requirement for replanting • relatively robust (can tolerate high stocking rates) and reliable system, even in dry conditions • contributes to soil nitrogen levels, halting soil fertility decline and improving the quality of companion grass • enables higher productivity and persistence of grasses with high nitrogen requirements, for example green or Gatton panic, Rhodes and buffel grass	• not suited to shallow, infertile soil types • successful establishment requires a high level of expertise • can be difficult to achieve optimal leucaena–grass balance and thus optimal animal performance • under ideal growing conditions leucaena plants can exceed the optimal height for grazing, resulting in additional costs for chopping/slashing • cattle require the rumen fluid inoculum to prevent mimosine and DHP toxicity that reduce cattle weight gains • during periods of cool, humid conditions, and especially in coastal regions, incidence of psyllids can reduce leucaena forage production • additional infrastructure costs may be required, e.g. fencing, trap-gates, laneways and water points • can become a weed when managed inappropriately • provides limited to no feed value in winter

Strengths/benefits	Constraints/threats
Butterfly pea–grass	
• produces high quality feed for most of the year, which increases both animal performance and stocking rate • a medium-term perennial pasture system (5–10 years) negating the requirement for annual forage replanting • large seed enables sowing into soil moisture for reliable establishment • contributes to soil nitrogen levels, halting soil fertility decline and improving the quality of companion grasses • can reduce nitrogen fertiliser requirements in subsequent crop rotations when used as a short- or long-term ley • enables higher productivity and persistence of grasses with high nitrogen requirements, for example green or Gatton panic, Rhodes and buffel grass	• not suited to shallow, infertile soil types • can be difficult to maintain an adequate proportion of legume in the pasture, especially with competitive perennial grasses • reduced production and life of butterfly pea under difficult situations such as drought, shallow soil depth or heavy grazing pressure • provides limited to no feed value in winter

References and further information

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9 Measured data for forages grown commercially in the Fitzroy River catchment

As part of the MLA and DAF co-funded project, "High-output forage systems for meeting beef markets – Phase 2", 24 forage sites were established on 12 producer co-operator properties across the Fitzroy River catchment from 2011 to 2014. The objective was to benchmark forage production systems on commercial co-operator properties to improve the understanding of expected forage, animal and economic performance, and the key drivers of profitability, within these systems.

The forage sites were selected in three regions within the catchment area: Central Queensland Open Downs (Emerald-Capella area), Central Queensland Brigalow (Biloela-Rolleston area), and South Queensland Brigalow (Taroom-Wandoan area). The forage types studied were the annuals: oats, forage sorghum and lablab, and the perennial pastures: leucaena–grass and butterfly pea–grass. A perennial grass pasture was also studied in each of the three regions to provide a baseline for comparison to the more highly productive forage options.

At each forage site, detailed data was collected to:

- characterise the soil and measure soil fertility (soil type, depth, nutrient composition, plant available water capacity and moisture at planting);
- record all paddock and livestock operations (e.g. planting and maintenance operations, cattle movements and treatments);
- measure rainfall and temperature, using on-site weather stations where possible or otherwise property records or the nearest BOM station;
- monitor forage biomass, species composition in perennial pastures, plant composition (e.g. % green leaf) and nutrient composition (crude protein and dry matter digestibility);
- monitor the quality of the diet selected by cattle over time, in terms of crude protein and dry matter digestibility, using faecal near infrared reflectance spectroscopy (NIRS) technology;
- characterise the cattle (breed, age, sex, grazing history) and measure cattle liveweight change;
- record all costs and returns associated with the paddock to enable a representative paddock gross margin to be calculated.



The producers at each site used their normal management practices and were not asked to change practices for the project, other than measuring cattle liveweight gain, if they did not already do so. The grazing management at forage sites was often complex, with a number of different groups of cattle grazing the forage, sometimes at different stages of the crop's grazing period, and cattle entering and exiting periodically to maintain suitable grazing pressure and as they reached target market specifications. Hence, daily liveweight gain data for individual groups of cattle is not presented here but rather the overall calculated total liveweight gain from the paddock (kg/ha/annum) is presented for simplicity. More detail about each of these co-operator sites, including the daily liveweight gain of individual groups of cattle and an explanation of how the gross margins were calculated, are given in Appendix 1 of the final report for this project, available from www.mla.com.au.

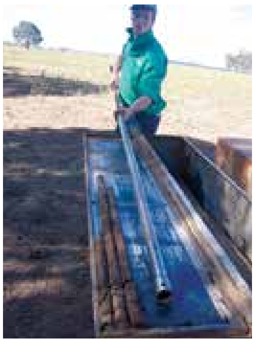


A summary of the crop data sets and key performance figures is given in Table 13. A one page summary of the key data and conclusions from each of the 24 sites is also provided at the end of this chapter. The data from these individual forage sites are influenced by the complex combination of management decisions, prevailing weather and market factors at the time, and should be interpreted in this light. While the sites give an insight into current industry practices and associated profitability of high quality forages, caution should be exercised in extrapolating the performance documented at these sites to the rest of industry. Terms and abbreviations used in the summary tables are given at the start of this guide.

Table 13. Summary of forage data sets and key performance figures. Values are the average (and range) across data sets for each forage type

	Annual forages			Perennial forages		
Forage type	**Oats**	**Forage sorghum**	**Lablab**	**Leucaena–grass[A]**	**Butterfly pea–grass**	**Perennial grass**
Region × number of data sets (full 12-month periods for perennials)	CQOD × 2 CQB × 3 SQB × 3	CQOD × 1 CQB × 2 SQB × 2	CQOD × 1 CQB × 1	CQOD × 2 CQB × 2 SQB × 1	CQOD × 2 CQB × 1	CQOD × 2 CQB × 1 SQB × 2
Forage biomass measurements in the grazed paddock (kg DM/ha); peak biomass for annuals, average over 12-months or total period for perennials	4555 (2278–5425)	12150 (2069–30197)	6014 (5484–6543)	Leucaena: 417 (196–744) Grass: 3809 (2700–5620)	Butterfly pea: 528 (143–1138) Grass: 4591 (3480–5519)	3702 (2186–4549)
Total grazing days per annum or total period	116 (91–158)	107 (52–139)	107 (103–111)	284 (140–476)	181 (139–223)	224 (0–476)
Total LWG (kg/ha per annum or total period) per total grazing area	93 (38–144)	108 (41–253)	99 (41–156)	198 (129–306)	125 (50–245)	76 (0–169)
Gross margin ($/ha per annum or total grazing period) per total grazing area; owner rates	131 (54–197)	54 (–48–243)	44 (38–50)	184 (90–304)	143 (34–379)	98 (–5–285)

CQOD: Central Queensland Open Downs, CQB: Central Queensland Brigalow, SQB: South Queensland Brigalow
A Figures for leucaena biomass represent only the edible material (i.e. leaves and stems up to 5 mm in diameter).



Key messages and conclusions from the co-operator sites

Forage and animal production

- Sown annual and perennial legume–grass forages can significantly increase beef output (kg/ha/annum) compared to that from perennial grass pastures.
- Leucaena–grass pastures resulted in the highest average total beef production (198 kg/ha/annum across all sites and all years) of all annual and perennial forage systems monitored in this project. The next highest average was for butterfly pea–grass pastures (125 kg/ha/annum). Furthermore, there was less variability between sites and years in total beef production from leucaena–grass pastures compared to butterfly pea–grass pastures or perennial grass-only pastures.
- Forage sorghum, despite producing twice as much forage biomass as the other annual forages, oats and lablab, on average resulted in only slightly higher total beef production. This was due to poor utilisation of forage sorghum biomass in many instances as well as a lower quality diet and hence lower individual animal production from forage sorghum.
- Of the sites monitored, soil fertility was generally low and fertiliser application was not common practice. It is likely that both soil nitrogen and phosphorus fertility may be limiting production of many annual forage crops in the Fitzroy River catchment. Phosphorus fertility may be limiting production of perennial legume–grass pastures. Whilst forage and animal production are currently sufficient to produce positive paddock gross margins in most cases, soil fertility levels will eventually reach critical levels for forage and beef production. Despite the generally low soil nitrogen levels, the annual forage crop yields were considered moderate to high at the majority of the co-operator sites. However, reasonable rainfall occurred at most sites and very high rainfall was received in one year of monitoring (2012). The generally low soil nitrogen levels resulted in low to very low forage crude protein levels at many sites. For example, 4.5% crude protein was measured in green leaf at the start of grazing of the unfertilised South Queensland Brigalow Oats 2011 crop.
- Grazing management practices in some cases may be limiting productivity and profitability of annual forage crops.
  - Forage sorghum crops are difficult to manage to optimise forage quality and therefore animal production. A common problem at many forage sorghum co-operator sites was starting grazing too late when the crop had started to mature and using stocking rates that were too low which allowed the crop to continue maturing. The most obvious example of this scenario is the Central Queensland Brigalow Forage sorghum 2011–12 crop where grazing commenced just prior to head emergence at 30 000 kg DM/ha of forage sorghum and a height of 316 cm, which was estimated to be about 6 weeks later than ideal for optimising forage quality. Despite the large forage biomass produced in this paddock only 53 kg of beef was produced per ha due to poor utilisation.
  - The opposite scenario can also occur, particularly with forage oats. Grazing too early, and with a high stocking rate, while the crop is still developing can decrease crop yields and hence total cattle production below the potential for that crop. This occurred with the Central Queensland Brigalow Oats 2011 crop.

- Some producers are not inoculating cattle grazing leucaena–grass pastures with the rumen fluid inoculum, or using carrier cattle. This may be causing sub-clinical mimosine and dihydroxypyridine (DHP) toxicity which will reduce cattle growth rates.
- Hormonal growth promotants (HGPs) were not commonly used in cattle grazing the high quality forages monitored in this project. There was often insufficient information available from the co-operators on cattle price data and target markets to accurately discern the reasons for the lack of use of HGPs and whether this could be decreasing potential profits.
- Monitoring of cattle weight gain during grazing periods on high quality forages may allow more optimal timing of sale. Many producers contacted in the process of engaging co-operators for this project commented that they do not usually monitor weight gain of cattle on forages. Those producers that do monitor weight gain generally only weigh at the start and end of a grazing period.
- A significant proportion of cattle grazing annual forage crops in this project were not sold directly to market but returned to perennial grass pastures after grazing the crop. This was either because: the forage was being used to spell pastures (particularly for forage sorghum crops), weaners or younger cattle were fed, or a proportion of the mob did not attain desired finishing weights or fat cover. In these cases, the gross margins calculated, were not actually realised by the producers, as although the cattle were valued upon exiting the forage, they were not actually sold. For these cases, the true economic benefit of feeding the annual forage crops would have to be determined on an individual basis by examining the effect on the profit of the whole farm business. However, it is clear that where cattle graze wet season perennial pastures in the summer season after grazing a forage oats crop it is highly likely that compensatory gain effects would erode any liveweight advantage provided by forage oats. This would likely make the venture unprofitable when considered in the context of overall farm profitability.
- Very high stocking rates were used on some perennial grass-only paddocks in some years. Some of these pastures were showing signs of becoming 'run-down' in terms of pasture composition and yield and would benefit from legume inclusion. This scenario appears to be typical of many perennial grass pastures across the Fitzroy River catchment.

Economics

- Gross margins are the first step in determining the effect of sown forages on farm profit. They show whether the forage activity itself makes a profit or a loss, at the paddock level.
- Market prices
  - Each gross margin was calculated using the relevant market price for the livestock at the time they entered the forage and at the time they left the forage. This means that the gross margins calculated for each co-operator site not only reflect the production circumstances of the forage but also the market circumstances prevailing over the production period of each of the forages.
  - Figure 4 shows the variation in store steer prices at Roma and Gracemere over the life of the project. It can be seen that the variability over any time period is significant and that the middle period of the project is dominated by a marked fall in prices followed by a moderate recovery. These market influences must be incorporated into any consideration of the gross margins calculated at co-operator sites.

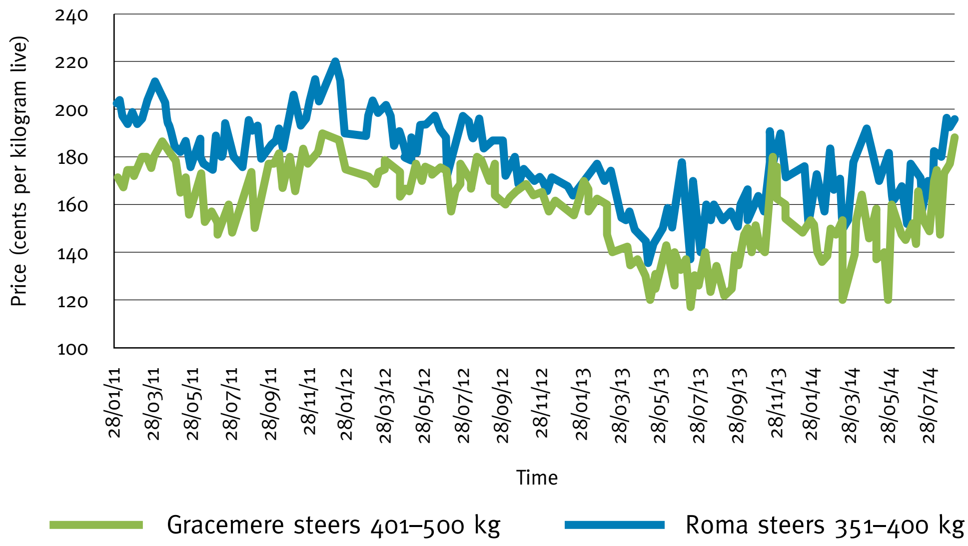


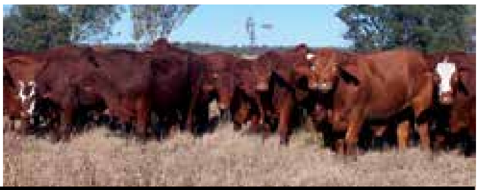
Figure 4. Store cattle prices over time at the Roma and Gracemere saleyards.

- As expected, there was a wide range in the profitability of the annual and perennial forages grown at the co-operator sites, both within and across forage types. Profitability was strongly influenced by forage and beef production (kg/ha), forage costs and cattle price margin (sale price less purchase price). These factors were in turn influenced by management, seasonal and market factors.
- There was no single over-riding factor that determined the profitability of forage systems. This demonstrates the importance of optimising all contributing factors, within the producer's control, in order to maximise the profitability of sown forage systems.
- Leucaena–grass sites had the highest average gross margin ($184/ha/annum, averaged across all sites and years).

- It is important to remember that the paddock gross margins are only the first step in determining the effect of sown forages on farm profitability. To determine the value of the sown forage system to the “whole farm” or business, a more complete economic analysis is required to consider the business operation with and without forages and to compare the net profit generated by alternative operating systems. Furthermore, adjustments are required to account for changes in unpaid labour and capital that would be likely to occur as a result of changes to the overall production system. The five whole farm case studies conducted with producer co-operators, reported in Chapter 8, give an insight into the effects of sown forages on whole farm profitability in the Fitzroy River catchment.

Site summaries

Central Queensland Open Downs—Oats (2011)



Site description & history	
Land & soil type	Open downs; open downs cracking clay on basalt
Paddock history	Cleared in 1982, cereal cropped for approx. 22 yrs then used for cereal and legume forages for the last 7 yrs
Soil depth & PAWC	90 cm; 220 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 7 mg/kg, P: 15 mg/kg, Organic C: 1.1%, Cl: 17 mg/kg
Forage production	
Total grazing area	164 ha
Area planted to forage	22 ha (13%)
Planting date	28/04/11
Sowing rate & variety	32 kg/ha; Drover
Fertiliser	None
Fallow weed control	Minimal till (cultivation and chemical application)
Planting soil moisture	202 mm
Total in-crop rainfall	110 mm
Green leaf at start of grazing	74% of biomass, 13.1% CP, 81% DMD
Peak biomass	Paddock: 5180 kg/DM; Exclosure: >4939 kg DM/ha
Average % oats in diet	83% (d 14–85)
Average diet quality	61% DMD (d 14–85)
Cattle production	
Cattle	Steers; 50% *B. indicus*; 89 hd ~2.5 yrs old and 40 hd ~1.5 yrs old at entry
Total grazing period	20/07/11 to 25/10/11 (97 d)
Average stocking rate	0.6 AE/ha total area; 4.6 AE/ha forage area only
Total LWG	38 kg/ha total area; 282 kg/ha forage area only

Economics

	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	403	54
Forage costs	193	26
Gross margin—contract rates	285	38
Forage costs	310	42

Conclusions

- Grazing commenced when the oats biomass was 2415 kg DM/ha and still developing, resulting in optimal diet quality at the start of grazing.
- Although the area of oats forage was only 13% of the total grazing area, oats was the major proportion of the diet (70–92% over the grazing period).
- Daily weight gain of the 2.5 year-old steers over the first 34 days of grazing was only 0.70 kg/head/day despite the diet quality and available biomass. However, the steers were close to their mature weight and size upon entry (622 kg).
- Daily weight gain over the last 45 days of grazing for the 1.5 year-old steers was 0.95 kg/head/day which was relatively high considering the oats crop was declining in quality at this time.
- Total beef production of 38 kg/ha of total grazing area was low as the oats forage formed only 13% of the total area.
- Forage costs were the highest of all 8 oats sites monitored.
- The average cattle price margin was $0.16/kg LW.
- The gross margin was low when expressed per total grazing area ($54/ha) but high when expressed per forage area ($403/ha).

Central Queensland Brigalow—Oats (2011)

Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Cleared in 1960s, re-cleared in 1984, cropped since with wheat or sorghum, then forage oats for last 6 yrs
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 23 mg/kg, P: 10 mg/kg, Organic C: 0.8%,Cl: 18 mg/kg
Forage production	
Total grazing area	60 ha
Area planted to forage	47 ha (78%)
Planting date	22/03/11
Sowing rate & variety	25 kg/ha; Dawson
Fertiliser	28 kg N/ha prior to planting
Fallow weed control	Minimal till (cultivation and chemical application)
Planting soil moisture	175 mm
Total in-crop rainfall	261 mm
Green leaf at start of grazing	77% of biomass, 21.4% CP, 80% DMD
Peak biomass	Paddock: 2278 kg DM/ha; Exclosure: 6609 kg DM/ha
Average % oats in diet	64% (d 23–138)
Average diet quality	66% DMD (d 23–138)
Cattle production	
Cattle	Steers; ~50% *B. indicus*; ~2.5 yrs at entry.
Total grazing period	26/05/11 to 31/10/11 (158 d)
Average stocking rate	1.5 AE/ha total area; 1.9 AE/ha forage area only
Total LWG	89 kg/ha total area; 113 kg/ha forage area only

Economics		
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	93	73
Forage costs	164	128
Gross margin—contract rates	16	12
Forage costs	241	188

Conclusions

- Grazing commenced at only 1177 kg DM/ha when the crop was still developing. It is likely that early and heavy grazing reduced plant growth and the quantity and quality of forage available.
- In addition, the steers were close to their mature weight and size upon entry (566 kg LW).
- The combined result was low average cattle growth rate of 0.47 kg/head/day (over average grazing period of 82 days, range 25–158 days).
- Total beef production of 89 kg/ha total area was moderate due to the combined effect of low daily growth rates, long grazing period and relatively high stocking rate.
- Forage costs were relatively high compared to other oats sites monitored.
- The cattle price margin was $0.06/kg LW.
- The combined result was a gross margin of $73/ha of total grazing area.

South Queensland Brigalow—Oats (2011)

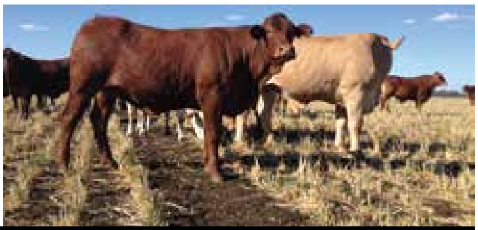
Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Farmed for forage production for approx. 30 yrs
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 7 mg/kg, P: 16 mg/kg, Organic C: 1.1%, Cl: 18 mg/kg
Forage production	
Total grazing area	125 ha
Area planted to forage	85 ha (68%)
Planting date	10/04/11
Sowing rate & variety	33.6 kg/ha; Moola
Fertiliser	None
Fallow weed control	Full cultivation
Planting soil moisture	150 mm
Total in-crop rainfall	325 mm
Green leaf at start of grazing	35% of biomass, 4.5% CP, 83% DMD
Peak biomass	Paddock: 4723 kg DM/ha; Exclosure: 5704 kg DM/ha
Average % oats in diet	63% (d 29–86)
Average diet quality	55% DMD (d 29–86)
Cattle production	
Cattle	Steers; ~25% *B. indicus*; 18–24 mths at entry, 100 d HGP
Total grazing period	27/07/11 to 26/10/11 (91 d)
Average stocking rate	1.3 AE/ha total area; 1.9 AE/ha forage area only
Total LWG	63 kg/ha total area; 92 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	290	197
Forage costs	93	63
Gross margin—contract rates	250	170
Forage costs	133	90

Conclusions

- Same paddock monitored as for SQ Brigalow Oats 2012 and 2013.
- Grazing commenced when the crop was fully developed and at peak biomass and hence the proportion of leaf was less than stem (35 vs 54% of the biomass) and diet quality less than optimal.
- Very low oats CP content, probably due to high rainfall in fallow period and leaching of soil nitrate. Soil nitrate N at planting was 42 kg/ha.
- Daily cattle growth rates of 0.79 kg/head/day for the first 63 days of grazing were low but still higher than expected given the very low CP content of oats forage.
- Total beef production of 63 kg/ha was the 2nd lowest of all 8 oats sites monitored (and the lowest when production is only considered in relation to the forage area: 92 kg/ha of forage area).
- Forage costs were amongst the lowest of all oats sites monitored due to the use of heavy machinery with lower costs/ha.
- The cattle price margin was $0.20/kg LW.
- The combined result was a very good gross margin of $197/ha of total grazing area, the greatest of all 8 oats sites.

Central Queensland Brigalow—Oats (2012)

Site description & history	
Land & soil type	Open downs and heavy clay alluvial; black cracking clay
Paddock history	Annual forage oats crops since clearing in 2004
Soil depth & PAWC	Average 90 cm; average 180 mm
Soil nutrients at planting	Not available
Forage production	
Total grazing area	603 ha
Area planted to forage	340 ha (56%), 10% of crop failed due to inundation
Planting date	15/03/12 to 05/04/12
Sowing rate & variety	25 kg/ha; 70% Aladdin, 30% Genie
Fertiliser	None
Fallow weed control	Zero till
Total in-crop rainfall	258 mm
Green leaf at start of grazing	65% of biomass, 14.9% CP, 77% DMD
Peak biomass	Paddock: 4263 kg/DM; Exclosure: 16 456 kg DM/ha
Average % oats in diet	100% (d 42); grain bins added for last 51 d
Average diet quality	65% DMD (d 42)
Cattle production	
Cattle	25-30% *B. indicus*; majority were steers or spayed heifers, either 2 or 3 years at entry
Total grazing period	15/06/12 to 03/10/12 (110 d)
Average stocking rate	1.0 AE/ha total area; 1.7 AE/ha forage area only
Total LWG (incl. grain)	144 kg/ha total area; 257 kg/ha forage area only

Economics

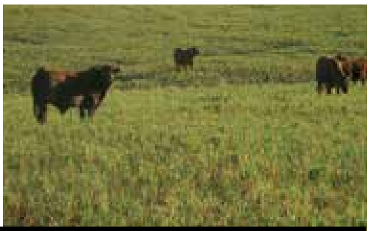
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	256	144
Forage costs	102	58
Grain feeding costs	54	30
Gross margin—contract rates	222	125
Forage costs	136	77

Conclusions

- Grazing commenced when the oats crop was still developing. This led to a high quality diet for cattle and very high growth rates greater than 1.5 kg/head/day over the first 59 days of grazing.
- Very high peak exclosure biomass (16 456 kg DM/ha) indicated very high total biomass grown in the paddock.
- Total beef production of 144 kg/ha of total grazing area was the highest of all 8 oats sites monitored but included the benefit of grain feeding for the last 51 days of the grazing period.
- Forage costs were amongst the lowest of all oats sites monitored.
- The average cattle price margin was $0.10/kg LW.
- The combined result was a gross margin of $144/ha of total grazing area.

South Queensland Brigalow—Oats (2012)





Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Farmed for forage production for approx. 30 yrs
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients	Not available
Forage production	
Total grazing area	125 ha
Area planted to forage	85 ha (68%)
Planting date	17/04/12
Sowing rate & variety	33.6 kg/ha; Genie
Fertiliser	None
Fallow weed control	Zero till
Planting soil moisture	73 mm
Total in-crop rainfall	288 mm
Green leaf on Day 63 of grazing	7.4% of biomass, 6.3% CP, 75% DMD
Peak biomass	Paddock: 4921 kg DM/ha; Exclosure: >7182 kg DM/ha
Average % oats in diet	72% (d 17–139)
Average diet quality	62% DMD (d 17–139)
Cattle production	
Cattle	Steers; ~25% *B. indicus*; 18–24 mths at entry, 100 d HGP
Total grazing period	04/07/12 to 19/11/12 (138 d)
Average stocking rate	1.0 AE/ha total area; 1.4 AE/ha forage area only
Total LWG	141 kg/ha total area; 208 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	231	157
Forage costs	109	74
Gross margin—contract rates	201	136
Forage costs	139	95

Conclusions

- Same paddock monitored as for SQ Brigalow Oats 2011 and 2013.
- Relatively long grazing period due to relatively low stocking rate and good in-crop rainfall.
- Grazing commenced when the oats biomass was only 2391 kg DM/ha and still developing, resulting in a high quality diet for cattle and high growth rates of 1.47 kg/head/day over the first 79 days of grazing.
- The total beef production of 141 kg/ha of total grazing area was the 2nd highest of all 8 oats sites monitored.
- Forage costs were amongst the lowest of all oats sites monitored.
- The cattle price margin was $0.08/kg LW.
- The combined result was a gross margin of $157/ha of total grazing area.

Central Queensland Open Downs—Oats (2013)



Site description & history	
Land & soil type	Open downs; black cracking clay
Paddock history	Cleared in 1980s. Organic grain cropped until 2003, and since then used for forage crops–lablab, sorghum and oats
Soil depth & PAWC	Average 90 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 37 mg/kg, P: 15 mg/kg, Organic C: 1.1%, Cl: <10 mg/kg
Forage production	
Total grazing area	140 ha + additional grass pdk of 210 ha for last 39 d
Area planted to forage	140 ha (83% average for total period)
Planting date	20/04/13
Sowing rate & variety	25 kg/ha; Aladdin
Fertiliser	32 kg N/ha prior to planting
Fallow weed control	Cultivation
Planting soil moisture	100 mm
Total in-crop rainfall	78 mm
Green leaf at start of grazing	67% of biomass, 11.4% CP, 77% DMD
Peak biomass	Paddock: 5425 kg DM/ha; Exclosure: 12 010 kg DM/ha
Average % oats in diet	89% (d 11–74)
Average diet quality	66% DMD (d 11–74)
Cattle production	
Cattle	Steers; ~13–38% *B. indicus*; 20–24 mths at entry
Total grazing period	22/07/13 to 22/10/13 (92 d)
Average stocking rate	1.2 AE/ha total area; 2.0 AE/ha forage area only
Total LWG	108 kg/ha total area; 177 kg/ha forage area only

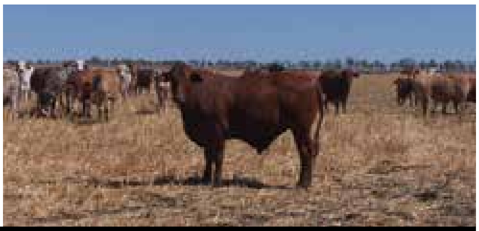
Economics

	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	214	131
Forage costs	158	97
Gross margin—contract rates	150	92
Forage costs	221	135

Conclusions

- Grazing commenced when the crop was still developing. This led to a high quality diet for cattle and cattle growth rates of 0.93 kg/head/day (average over entire 92 days of grazing).
- Total beef production of 108 kg/ha of total grazing area was moderate relative to other sites due to the combined effect of good daily cattle growth rates, and moderate total grazing days and stocking rate.
- Forage costs were in the middle of the range of that calculated for the 8 other oats sites.
- The cattle price margin was $0.37/kg LW.
- Combined result was a gross margin of $131/ha of total grazing area.

Central Queensland Brigalow—Oats (2013)



Site description & history	
Land & soil type	Open downs and heavy clay alluvial; black cracking clay
Paddock history	Cleared in 1970s, annual grain crops to 1999 then mainly forage crops
Soil depth & PAWC	Average 90 cm; average 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 9.4 mg/kg, P: 32 mg/kg, Organic C: 0.68%, Cl: 10 mg/kg
Forage production	
Total grazing area	223 ha
Area planted to forage	79 ha (36%)
Planting date	18/03/13 to 19/03/13
Sowing rate & variety	25 kg/ha; Genie
Fertiliser	55 kg N/ha
Fallow weed control	Zero till
Planting soil moisture	118 mm
Total in-crop rainfall	125 mm
Green leaf at start of grazing	55% of biomass, 16.3% CP, 77% DMD
Peak biomass	Paddock: 4476 kg DM/ha; Exclosure: >5965 kg DM/ha
Average % oats in diet	78% (d 17–113), grain bins added for 10 d from day 67
Average diet quality	64% DMD (d 17–113)
Cattle production	
Cattle	Steers; 25–30% *B. indicus;* mix of 2 and 3 yr old
Total grazing period	11/06/13 to 01/11/13 (143 d)
Average stocking rate	0.8 AE/ha total area; 2.2 AE/ha forage area only
Total LWG (incl. grain)	81 kg/ha total area; 228 kg/ha forage area only

Economics		
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	497	177
Forage costs	175	62
Grain feeding costs	34	12
Gross margin—contract rates	433	154
Forage costs	239	85

Conclusions

- Grazing commenced when the crop was still developing (biomass 2918 kg DM/ha) resulting in optimal diet quality and good average cattle growth rates of 0.91 kg/head/day over the first 96 days of grazing.
- Total beef production of 81 kg/ha of total grazing area was only moderate despite the long grazing period (143 days) and good early growth rates. This was due to the low stocking rate and low cattle growth rates over the last 43 days of the grazing period (estimated as 0.57 kg/head/day).
- Forage costs were the 3rd highest of all 8 oats sites monitored.
- The average cattle price margin was $0.45/kg LW.
- The combined result was a very good gross margin of $177/ha of total grazing area, the 2nd highest of all oats sites monitored.

South Queensland Brigalow—Oats (2013)

Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Farmed for forage production for approx. 30 years
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 11 mg/kg, P: 36 mg/kg, Organic C: 1.1%, Cl: 12.0 mg/kg
Forage production	
Total grazing area	125 ha
Area planted to forage	85 ha (68%)
Planting dates	03/04/13 to 04/04/13
Sowing rate & variety	33.6 kg/ha; Aladdin
Fertiliser	None
Fallow weed control	Minimum till (cultivation and chemical application)
Planting soil moisture	72 mm
Total in-crop rainfall	108 mm
Green leaf at start of grazing	54% of biomass, 10.4% CP, 76% DMD
Peak biomass	Paddock: 5175 kg DM/ha; Exclosure: 6605 kg DM/ha
Average % oats in diet	65% (d 24–91)
Average diet quality	61% DMD (d 24–91)
Cattle production	
Cattle	Steers; ~25% *B. indicus*; 18–24 mths at entry, 100 d HGP
Total grazing period	30/07/13 to 05/11/13 (98 d)
Average stocking rate	0.9 AE/ha total area; 1.3 AE/ha forage area only
Total LWG	82 kg/ha total area; 121 kg/ha forage area only

Economics		
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	173	118
Forage costs	94	64
Gross margin—contract rates	136	92
Forage costs	131	89

Conclusions

- Same paddock monitored as for SQ Brigalow Oats 2011 and 2012.
- Low soil moisture at planting resulted in slow and patchy establishment and high weed presence.
- Grazing commenced when the oats biomass was 3478 kg DM/ha and still developing, resulting in optimal diet quality and good average cattle growth rates of 1.15 kg/head/day over the entire 98 days of grazing.
- Total beef production of 82 kg/ha of total grazing area was moderate due to the moderate grazing days and low stocking rate.
- Forage costs were the lowest of all 8 oats sites monitored due to minimal cultivation and herbicide operations.
- The cattle price margin was $0.23/kg LW.
- The combined result was a gross margin of $118/ha of total grazing area.

Central Queensland Brigalow—Forage Sorghum (2011–12)

Site description & history	
Land & soil type	Open downs and heavy clay alluvial; black cracking clay
Paddock history	Cleared in 1999–2000, cropped for 8 of the following 12 yrs with mainly forage sorghum
Soil depth & PAWC	Average 90 cm; average 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 7.9 mg/kg, P: 23 mg/kg, Organic C: 1.0%, Cl: 10 mg/kg
Forage production	
Total grazing area	603 ha
Area planted to forage	365 ha (61%)
Planting date	18/12/11 to 23/12/11
Sowing rate & variety	5.5 kg/ha; Sugargraze
Fertiliser	49 kg N/ha prior to planting
Fallow weed control	Minimal till (cultivation and chemical application)
Planting soil moisture	110 mm
Total in-crop rainfall	502 mm
Green leaf at start of grazing	19.6% of biomass, 14.2% CP, 68% DMD
Peak biomass	Paddock: 30 197 kg DM/ha; Exclosure: >35 598 kg DM/ha
Average diet quality	6.6% CP: 53% DMD (d 11-113)
Cattle production	
Cattle	25–30% *B. indicus*; steers or spayed heifers, either 1 or 2 years at entry
Total grazing period	24/02/12 to 15/06/12 (112 d)
Average stocking rate	1.3 AE/ha total area; 2.2 AE/ha forage area only
Total LWG	53 kg/ha total area; 87 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	20	12
Forage costs	169	102
Gross margin—contract rates	–78	–47
Forage costs	267	162

Conclusions

- High seeding rate, planting soil moisture and rainfall resulted in very high biomass at the start of grazing (30 197 kg DM/ha) which was estimated to be about 6 weeks later than ideal for maximising forage quality (green leaf was only 20% of the biomass at start of grazing).
- The quality of the forage was the limiting factor for cattle growth rates at this site (average for different cattle classes ranged from 0.23–0.37 kg/head/day over entire grazing period of 112 days).
- 1-year old heifers were spayed immediately prior to entering forage sorghum and this may have contributed to their growth rates being 23% less than that of steers from the same age cohort (0.23 vs 0.30 kg/head/day).
- Total beef production of 53 kg/ha of total grazing area was the 2nd lowest of all 5 sorghum sites monitored due to the combined effect of low daily cattle growth rates and the low stocking rate.
- Forage costs were the highest of all sorghum sites monitored.
- The average cattle price margin was $0.10/kg LW.
- The combined result was a poor gross margin of $12/ha of total grazing area.

South Queensland Brigalow—Forage Sorghum (2011–12)


Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Farmed for approx. 20 yrs with mostly forage oats, some forage sorghum for silage in earlier years
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 12 mg/kg, P: 17 mg/kg, Organic C: 1.4%, Cl: 24 mg/kg
Forage production	
Total grazing area	77.7 ha
Area planted to forage	56.5 ha (73%)
Planting date	02/12/11 to 18/12/11
Sowing rate & variety	2.3 kg/ha; Sugargraze
Fertiliser	None
Fallow weed control	Full cultivation
Planting soil moisture	53 mm
Total in-crop rainfall	375 mm
Green leaf at start of grazing	30% of biomass, 11.4% CP, 66% DMD
Peak biomass	Paddock: 16 604 kg DM/ha; Exclosure: 14 814 kg DM/ha
Average diet quality	10.3% CP, 57% DMD, (d 15–60)
Cattle production	
Cattle	Steers; ~30% *B. indicus*; 1.3 and 2.3 yrs old at entry
Total grazing period	21/02/12 to 08/06/12 (108 d)
Average stocking rate	2.4 AE/ha total area; 3.3 AE/ha forage area only
Total LWG	140 kg/ha total area; 192 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	333	243
Forage costs	125	91
Gross margin—contract rates	268	196
Forage costs	190	139

Conclusions

- Grazing commenced when the crop was already quite mature (biomass of 16 604 kg DM/ha) with leaf forming only 30% of the biomass. Diet quality at the start of grazing was less than optimal but the relatively high stocking rate maintained forage quality at a level sufficient to sustain reasonable cattle growth rates.
- The daily cattle growth rate for 1-year old steers of 0.59 kg/head/day over the entire grazing period of 108 days was considered reasonable for forage sorghum. Daily growth rates were much lower for the six 2-year old steers monitored (0.15 kg/head/day).
- Total beef production of 140 kg/ha for the total grazing area was 2nd highest of all 5 sorghum sites monitored due to the combined effect of reasonable daily cattle weight gain and the relatively high stocking rate.
- Forage costs were the 2nd highest of all sorghum sites monitored.
- The average cattle price margin was $0.12/kg LW.
- The combined result was a good gross margin of $243/ha of total grazing area, the highest of all sorghum sites monitored.

Central Queensland Open Downs—Forage Sorghum (2012–13)

Site description & history	
Land & soil type	Brigalow undulating plain; black cracking clay
Paddock history	Cleared in 1960s, then cultivated for approx. 40 yrs with sunflower, wheat, grain and forage sorghum
Soil depth & PAWC	Average 90 cm; average 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 6 mg/kg, P: 16 mg/kg, Organic C: 1.3%, Cl: 10 mg/kg
Forage production	
Total grazing area	385 ha + additional grass pdk of 100 ha for last 91 d
Area planted to forage	229 ha (50% average for total period)
Planting date	10/02/13
Sowing rate & variety	8 kg/ha; Sugargraze
Fertiliser	None
Fallow weed control	Zero till
Planting soil moisture	Not available
Total in-crop rainfall	190 mm
Green leaf at start of grazing	23% of biomass, 14.3% CP, 65% DMD
Peak biomass	Paddock: 9573 kg/DM; Exclosure: 9573 kg DM/ha
Average diet quality	7.2% CP, 52% DMD (d 3–97)
Cattle production	
Cattle	Steers; ~44% *B. indicus*; 2 yrs old at entry.
Total grazing period	17/04/13 to 19/08/13 (124 d)
Average stocking rate	0.9 AE/ha total area; 1.7 AE/ha forage area only
Total LWG	41 kg/ha total area; 82 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	87	41
Forage costs	24	12
Gross margin—contract rates	61	29
Forage costs	50	24

Conclusions

- Low planting soil N and moisture resulted in poor forage establishment and competition from weeds, and thus in a relatively low forage biomass at start of grazing of 9573 kg DM/ha. In addition, the maturity of the crop at the start of grazing was estimated to be about 6 weeks later than ideal for maximising forage quality (green leaf was only 23% of the biomass at start of grazing).
- The quality of the forage was the limiting factor for cattle growth rates at this site with the average over the entire grazing period of 124 days being 0.43 kg/head/day.
- Total beef production of 41 kg/ha of total grazing area was low due to the combined effect of low daily cattle growth rates and the low stocking rate.
- Forage costs were relatively low and the cattle price margin was $0.10/kg LW.
- The combined result was a gross margin of $41/ha of total grazing area.

Central Queensland Brigalow—Forage Sorghum (2012–13)


Site description & history	
Land & soil type	Alluvial plain; Heavy loam/light-medium clay
Paddock history	Cleared in ~ 1990, cropped since 1992 with forage or grain crops
Soil depth & PAWC	Average 120 cm; average 180 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 21 mg/kg, P: 130 mg/kg, Organic C: 1.8%, Cl: 12 mg/kg
Forage production	
Total grazing area	246 ha
Area planted to forage	198 ha (80%)
Planting date	03/12/12
Sowing rate & variety	4.5 kg/ha; Sugargraze
Fertiliser	40 kg N/ha
Fallow weed control	Minimal till (cultivation and chemical application)
Planting soil moisture	94 mm
Total in-crop rainfall	275 mm
Green leaf at start of grazing	56.8% of biomass, 13.3% CP, 64% DMD
Peak biomass	Paddock: 2308 kg/DM; Exclosure: 17 243 kg DM/ha
Average diet quality	10.1% CP, 58% DMD (d 4–113)
Cattle production	
Cattle	Steers; ~50–70% *B. indicus*; 1–1.5 yrs old at entry
Total grazing period	29/01/13 to 17/06/13 (139 d)
Average stocking rate	2.6 AE/ha total area; 3.3 AE/ha forage area only
Total LWG	253 kg/ha total area; 316 kg/ha forage area only

Economics	Forage area only; ($/ha)	Total area ($/ha)
Gross margin—owner rates	–60	–48
Forage costs	144	116
Gross margin—contract rates	–99	–80
Forage costs	184	148

Conclusions

- Grazing commenced during vegetative growth of the crop at 2208 kg DM/ha biomass and 57% green leaf, which was ideal for maximising forage quality.
- In addition, rotational grazing (the paddock was divided into 3 sections) and a relatively high stocking rate optimised forage quality over the duration of the grazing period.
- The result was a very high cattle growth rate for forage sorghum over the first 33 d of grazing: 1.1 kg/head/day.
- The estimated total beef production of 253 kg/ha of total grazing area was very high and the highest of all 5 sorghum sites monitored. This was due to the combined effect of good cattle growth rates, a long grazing period and a high stocking rate.
- Forage costs were moderate compared to other sorghum sites monitored.
- The cattle price margin was negative: –$0.02/kg LW.
- The combined result was a negative gross margin of –$48/ha of total grazing area.

South Queensland Brigalow—Forage Sorghum return crop (2012–13)

Site description & history	
Land & soil type	Brigalow; brown cracking clay
Paddock history	Farmed for approx. 20 yrs with mostly forage oats, some forage sorghum for silage in earlier years
Soil depth & PAWC	120 cm; 180 mm
Soil nutrients at planting (0–10 cm)	Not applicable: return crop from 2011/12 season
Forage production	
Total grazing area	77.7 ha
Area planted to forage	55.6 ha (73%)
Planting date	2011/12 crop planted 02/12/11 to 18/12/11
Sowing rate & variety	2.3 kg/ha; Sugargraze
Fertiliser	None
Fallow weed control	Herbicide application in mid Nov 2012
Total rainfall	413 mm (from end of 2011–12 in-crop period to end of 2012–13 grazing)
Whole plant at start of grazing	10.8% CP, 65% DMD
Peak biomass	Paddock: 2069 kg/DM
Average diet quality	10.0% CP, 57% DMD (d 4–52)
Cattle production	
Cattle	Steers; ~30% *B. indicus*; 1.3 and 2.3 yrs old at entry
Total grazing period	18/02/1 to 1/04/13 (52 d)
Average stocking rate	1.2 AE/ha total area; 1.6 AE/ha forage area only
Total LWG	54 kg/ha total area; 74 kg/ha forage area only

Economics		
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	30	22
Forage costs	16	12
Gross margin—contract rates	27	20
Forage costs	19	14

Conclusions

- This crop was a regrowth crop of forage sorghum. The original crop was monitored in the 2011–12 season.
- Grazing commenced when the return crop was 2069 kg DM/ha which was ~12.5% of the starting biomass of the original crop grazed in 2012 due to lower plant population and vigour and reduced tillering.
- The daily cattle growth rate for 1-year old steers of 1.1 kg/head/day over the entire grazing period of 52 days was almost twice that for 1-yr old steers grazing the original crop. Daily growth rates were lower for the 2-year old steers monitored: 0.70 kg/head/day.
- Total beef production of 54 kg/ha for the total grazing area was low due to the combined effect of good daily cattle weight gain but low total grazing days and stocking rate. The beef production was 39% of that from the original crop.
- Forage costs were very low.
- The average cattle price margin was $0.01/kg LW.
- The combined result was a positive gross margin of $22/ha of total grazing area.

Central Queensland Open Downs—Lablab (2011–12)

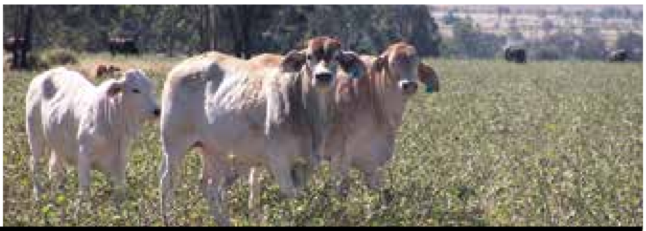
Site description & history	
Land & soil type	Heavy clay alluvial; black cracking clay
Paddock history	First cultivated in 2003–04, then cropped annually with either forage sorghum (3x), lablab (2x) or oats (1x)
Soil depth & PAWC	120 cm; 240 mm
Soil nutrients at planting (0–10 cm)	Nitrate N: 21 mg/kg, P: 23 mg/kg, Organic C: 0.86%, Cl: 12 mg/kg
Forage production	
Total grazing area	229 ha + additional grass pdk of 285 ha for last 62 d
Area planted to forage	219 ha (43% for last 62 d when LWG measured)
Planting date	17/12/11
Sowing rate & variety	22 kg/ha; Dolichos cv. Highworth
Fertiliser	None
Fallow weed control	Minimal till (cultivation and chemical application)
Planting soil moisture	100 mm
Total in-crop rainfall	576 mm
Green leaf at start of grazing	32% of biomass, 26.5% CP, 77% DMD
Peak biomass	Paddock: 5484 kg DM/ha; Exclosure: >5021 kg DM/ha
Average % lablab in diet	31% (d 29)
Average diet quality	9.9% CP, 58% DMD (d 29)
Cattle production	
Cattle	Steers; ~13-38% *B. indicus*; 20–24 mths at entry.
Total grazing period	02/03/12 to 13/06/12 (103 d)
Average Stocking Rate	0.6 AE/ha total area (final 62 d); 1.5 AE/ha forage area only
Total LWG	41 kg/ha total area; 96 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	89	38
Forage costs	85	36
Gross margin—contract rates	47	20
Forage costs	127	54

Conclusions

- Grazing commenced when biomass was 5484 kg DM/ha and green leaf formed only 32% of the biomass. After 80 days of grazing there was very little lablab green leaf remaining. There was a big difference between leaf and stem in CP and digestibility, with the CP in green stem being 52% less than in green leaf at the start of grazing.
- Despite the drop in high quality lablab leaf over the grazing period, steer weight gains measured over the final 62 days of the 103 day grazing period were in the range of that expected for steers grazing lablab forage: 0.81 kg/head/day.
- However, low stocking rates resulted in relatively low beef production: 41 kg/ha of total grazing area or 96 kg/ha of forage area only.
- Forage costs were relatively low.
- The cattle price margin was $0.12/kg LW.
- The combined result was a gross margin of $38/ha of total grazing area.

Central Queensland Brigalow—Lablab (2012–13)



Site description & history	
Land & soil type	Brigalow scrub; medium clay
Paddock history	Cleared late 1950s, cropped from 1960 to 1990, then a grass paddock for 20 yrs until cotton cropped in 2010–11 and wheat cropped in 2012
Soil depth & PAWC	120 cm; 160 mm
Soil nutrients 5 wks post planting (0–10 cm)	Nitrate N: 6.7 mg/kg, P: 15 mg/kg, Organic C: 0.62%, Cl: 10 mg/kg

Forage production	
Total grazing area	87 ha
Area planted to forage	64 ha (73%)
Planting date	06/02/13
Sowing rate & variety	15 kg/ha; Dolichos cv. Highworth
Fertiliser	None
Fallow weed control	Zero till
Soil moisture 5 wks post planting	76 mm
Total in-crop rainfall	328 mm
Green leaf at start of grazing	58% of biomass, 18.0% CP, 72% DMD
Peak biomass	Paddock: 6543 kg/DM; Exclosure: 14 253 kg DM/ha
Average % lablab in diet	76% (d 16–107)
Average diet quality	13.0% CP, 59% DMD (d 16–107)

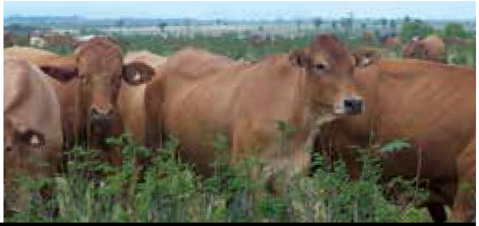
Cattle production	
Cattle	111 Brangus steers 18–24 mths at entry; 23 Brahman × steers and 20 Brahman × heifers, 8-10 mths at entry.
Total grazing period	17/04/13 to wo6/08/13 (111 d)
Average stocking rate	1.3 AE/ha total area; 1.8 AE/ha forage area only
Total LWG	156 kg/ha total area; 212 kg/ha forage area only

Economics	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	68	50
Forage costs	113	82
Gross margin—contract rates	21	15
Forage costs	160	117

Conclusions

- High in-crop rainfall resulted in high total biomass production as indicated by the peak biomass measured in the exclosure of 14 253 kg DM/ha.
- Grazing commenced when green leaf formed 58% of total biomass and thus diet quality was optimal at start of grazing. There was a big difference between leaf and stem CP and digestibility, with stem CP being 56% lower of than leaf CP at the start of grazing.
- Lablab formed a high proportion of the diet for the entire grazing period (76% average).
- The combined result was a high daily cattle weight gain, e.g. for 2-year old steers: 1.22 kg/head/day for first 90 days and 0.98 kg/head/day over the entire 111-day grazing period.
- Total beef production of 156 kg/ha of total grazing area was relatively high due to the combined effect of good daily weight gain and moderate stocking rates.
- Forage costs were relatively high compared to the other lablab site monitored.
- The average cattle price margin was negative: –$0.14/kg LW.
- The combined result was a gross margin of $50/ha of total grazing area.

Central Queensland Open Downs—Leucaena–grass (2012–14)



Site description & history		
Land & soil type	Open downs; black cracking clay	
Paddock history	Organic grain cropped until 2003 then forage sorghum or lablab cropping until 2007. Leucaena and perennial grasses sown in 2008. Maintenance chopping in 2011 and 2013	
Soil depth & PAWC	120 cm; 240 mm	
Soil nutrients (0–10 cm)	P: 11 mg/kg, Organic C: 1.5%	
Total monitoring period	**23/02/12 to 28/02/13**	**01/03/13 to 27/02/14**
Total days	**371**	**363**
Forage production		
Total grazing area	262 ha	
Area planted to leucaena	216 ha (82%)	
Planting details	2 kg/ha Cunningham leucaena, single rows, 10 m centres; 4.5 kg/ha perennial grasses	
Fertiliser	5.4 kg P/ha at planting	
Rainfall	671 mm	463 mm
Average edible leucaena quality	25.9% CP, 67% DMD	23.3% CP, 64% DMD
Average edible leucaena biomass	236 kg DM/ha	196 kg DM/ha
Average grass biomass	5620 kg DM/ha	4369 kg DM/ha
Average % leucaena in diet	44% (d 37-335)	48% (d 8-361)
Average diet quality	11.4% CP, 62% DMD	13.8% CP, 64% DMD
Cattle production		
Cattle	Steers; ~ 13–38% *B. indicus*; 5 groups ranging from 14–30 mths at entry	
Total grazing days per period	140	186
Average stocking rate	0.64 AE/ha	0.81 AE/ha
Total LWG (total area)	148 kg/ha	234 kg/ha
Economics		
	Gross margin expressed per total area, forage costs per forage area only; ($/ha)	
Gross margin—owner rates	142	192
Forage costs	35	35
Gross margin—contract rates	140	191
Forage costs	37	37

Conclusions

- This paddock was used in rotation with 3 other leucaena paddocks. Large groups of cattle were rotated through the paddocks with the average grazing period in the target paddock being 23 days. Grazing management and maintenance chopping strategies assisted in maximising forage production and quality. This in turn enabled high average paddock stocking rates and total beef production (average over the 2 years of 191 kg/ha/annum).
- However, soil P levels were considerably lower than what leucaena requires to attain maximum forage production potential (15–20 mg P/kg in top 10 cm).
- There was a wide range in cattle growth rates dependant on time of year and seasonal conditions. The lowest recorded was 0.31 kg/head/day over 194 days during the 2013 winter and spring period for 18–24 mth-old steers. The highest was 1.53 kg/head/day over 34 days in early autumn 2013 for 17-mth old steers.
- Forage costs were in the middle of the range of other leucaena–grass sites monitored.
- The average cattle price margin in both years was $0.00/kg LW.
- The combined result was an average gross margin for the total grazing area of $167/ha/annum, over the 2 years of monitoring.

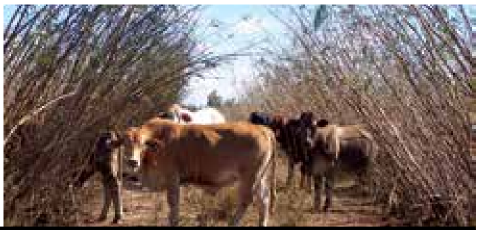
Central Queensland Brigalow—Leucaena–grass (2012–13)

Site description & history		
Land & soil type	Brigalow; brown cracking clay (with melonholes)	
Paddock history	Cleared in late 1960s, grain cropped until leucaena planted to 51.8 ha in 2001. Remaining 45.2 ha cleared in 1980s, blade ploughed and perennial grasses sown in 1990s, regrowth cleared again in mid 2000s	
Soil depth & PAWC	120 cm; 180 mm	
Soil nutrients (0–10 cm)	P: 20 mg/kg, Organic C: 1.2%	
Total monitoring period	**10/01/12 to 30/04/13**	
Total days	**476**	
Forage production		
Total grazing area	97.1 ha	
Area planted to leucaena	51.8 ha (53%)	
Leucaena planting (51.8 ha)	Cunningham leucaena, twin rows 1 m apart, 6 m centres	
Grass planting (45.2 ha)	green panic, buffel grass and butterfly pea	
Rainfall	1026 mm	
Average edible leucaena quality	23.1% CP, 67% DMD	
Average edible leucaena biomass	438 kg DM/ha	
Average grass biomass	2700 kg DM/ha	
Average % leucaena in diet	37% (d 25–477)	
Average diet quality	9.6% CP, 44% DMD (d 25–477)	
Cattle production		
Cattle	Steers; 100% *B. indicus*; 12–16 mths at entry	
Total grazing days per period	476	
Average stocking rate	0.65 AE/ha total area; 1.22 AE/ha leucaena only;	
Total LWG (total area)	129 kg/ha	
Economics		
	Forage area only ($/ha)	Total area ($/ha)
Gross margin—owner rates	169	90
Forage costs	47	25
Gross margin—contract rates	158	85
Forage costs	58	31

Conclusions

- Leucaena was planted to only 53% of the paddock area which had relatively lower fertility due to a history of grain cropping. Perennial grasses had not been sown between the leucaena rows and the naturalised grass biomass was almost 3 times lower than in the grass-only area and was >50% annual grasses and Indian bluegrass.
- The paddock was continuously grazed at 0.65 AE/ha.
- Drought conditions for much of 2012 (2012 rainfall total 470 mm) then extremely high rainfall for last 4 mths of grazing (557 mm).
- Average grass biomass over the total grazing area was low.
- The average cattle price margin was negative: –$0.16/kg LW.
- Cattle growth rates ranged from –0.07 kg/head/day over 197 days from Aug 2012 to mid Feb 2013, to 1.30 kg/head/day over the following 35 days after significant rainfall events. The average liveweight gain over the first 438 days of grazing from 10/01/12–23/03/13 was 0.39 kg/head/day.
- The resulting total beef production was only 86 kg/ha for the first 12 months but 129 kg/ha for the total 476 days which includes significant compensatory growth following the high rainfall totals in early 2013.
- Forage costs were relatively high compared to other leucaena–grass sites monitored.
- The combined result was a relatively low gross margin for the total grazing area of $90/ha/476 days.

Central Queensland Brigalow—Leucaena–grass (2013–14)



Site description & history		
Land & soil type	Alluvial; deep loam alluvial	
Paddock history	Leucaena area grain cropped until leucaena and perennial grasses planted in 2005. Maintenance chopping in 2012. Part of the paddock periodically floods including in early 2013	
Soil depth & PAWC	≥150 cm; 220 mm	
Soil nutrients (0–10 cm)	P: 110 mg/kg, Organic C: 1.6%,	
Total monitoring period	**08/04/13 to 08/04/14**	
Total days	**365**	
Forage production		
Total grazing area	100.1 ha	
Area planted to leucaena	66.5 ha (66%)	
Planting details	Cunningham leucaena, twin rows 1 m apart, 6 m centres; perennial grass sown twice	
Rainfall	567 mm	
Average edible leucaena quality	22.9% CP, 61% DMD	
Average edible leucaena biomass	744 kg DM/ha	
Average grass biomass	2746 kg DM/ha	
Average % leucaena in diet	61% (d 11–341)	
Average diet quality	12.9% CP, 63% DMD (d 11–341)	
Cattle production		
Cattle	Heifers & steers; ~ 50% *B. indicus*; 16–18 mths at entry	
Total grazing days per period	318	
Average stocking rate	0.87 AE/ha (total area)	
Total LWG	175 kg/ha	
Economics		
	Forage area ($/ha)	Total area ($/ha)
Gross margin—owner rates	458	304
Forage costs	35	24
Gross margin—contract rates	449	299
Forage costs	44	29

Conclusions

- The soil had high fertility and water holding capacity.
- The average leucaena biomass was the highest of all leucaena–grass sites monitored and resulted in a high average % leucaena in the diet: 61%.
- The total grazing days per annum was relatively high: 318 days. In addition, the average stocking rate over the total grazing area for the 365-day period was relatively high: 0.87 AE/ha.
- The lowest cattle growth rates were measured for steers grazing over the 2013 spring period: 0.29 kg/head/day for 75 days. The greatest growth rates were for heifers grazing during the 2013–14 summer to early autumn 2014: 0.94 kg/head/day over 121 days.
- The total beef production was 175 kg/ha/annum.
- Forage costs were relatively high compared to other leucaena–grass sites monitored.
- The average cattle price margin was $0.10/kg liveweight. The combined result was a gross margin of for the total grazing area of $304/ha/annum.

South Queensland Brigalow—Leucaena–grass (2012–13)

Site description & history		
Land & soil type	Brigalow/Belah; cracking clay	
Paddock history	Cleared in 1970s then grain cropped with wheat & oats. Leucaena planted in late 2007 and perennial grasses planted in 2008	
Soil depth & PAWC	120 cm; 160 mm	
Soil nutrients (0–10 cm)	P: 15 mg/kg, Organic C: 0.89%	
Total monitoring period	**25/02/12 to 17/02/13**	**18/02/13 to 10/06/13**
Total days	**358**	**112**
Forage production		
Total grazing area	101.2 ha	
Area planted to forage	101.2 ha (100%)	
Planting details	2.5 kg/ha Tarramba leucaena, twin rows 1 m apart, 6 m centres; 2.5 kg/ha Biloela buffel, 1 kg/ha silk sorghum	
Rainfall	606 mm	154 mm
Average edible leucaena quality	19.6% CP, 62% DMD	18.3% CP, 59% DMD
Average edible leucaena biomass	470 kg DM/ha	417 kg DM/ha
Average grass biomass	3610 kg DM/ha	2689 kg DM/ha
Average % leucaena in diet	62% (d 9–289)	70% (d 4–92)
Average diet quality	12.5% CP, 62% DMD	15.8% CP, 63% DMD
Cattle production		
Cattle	Steers; ~20% *B. indicus;* 6–20 mths at entry; 100 d HGP	Steers; ~20% *B. indicus;* 17–19 mths at entry; 100 d HGP
Total grazing days per period	300	51
Average stocking rate	0.82 AE/ha	2.48 AE/ha
Total LWG	306 kg/ha/annum (incl. grain)	108 kg/ha/112 days
Economics ($/ha)		
Gross margin—owner rates	193	Not applicable
Forage costs	17	Not applicable
Grain feeding costs	125	Not applicable
Gross margin—contract rates	188	Not applicable
Forage costs	21	Not applicable

Conclusions

- This paddock was used in rotation with up to 2 other leucaena paddocks.
- Good leucaena and forage biomass supported a high number of grazing days/period and high stocking rates.
- The average % of leucaena in the diet was high.
- Cattle growth rates for 2 groups monitored after the break of the season in early 2012 and 2013 were high: 1.52 kg/head/day over 30 days in early 2012 and 1.23 kg/head/day over 84 days in early 2013.
- Estimated total beef production was very high in the first 12-month period of monitoring: 306 kg/ha/annum, although this includes the benefit of grain feeding of 8 kg/head/day to 175 head for 30 days. Total beef production for the next 112 days of grazing was also very high: 108 kg/ha/112 days.
- Forage costs were low compared to other leucaena–grass sites monitored.
- The average cattle price margin for the first 12-month period was –$0.01/kg LW.
- The combined result was a gross margin for the first 12-month period of $193/ha/annum.

Central Queensland Open Downs—Butterfly pea–grass (2012–14)

Site description & history		
Land & soil type	Heavy clay alluvial; black cracking clay	
Paddock history	Organic grain cropped prior to 2004. Butterfly pea and perennial grasses sown over 2004–06	
Soil depth & PAWC	120 cm; 240 mm	
Soil nutrients (0–10 cm)	Not available	
Total monitoring period	**06/03/12 to 06/03/13**	**07/03/13 to 06/03/14**
Total days	**365**	**364**
Forage production		
Total grazing area	209 ha	
Area planted to butterfly pea	209 ha (100%)	
Planting details	11.5 kg/ha of butterfly pea and 4 kg/ha perennial grasses over 90 ha in Dec 2004, 8 kg/ha butterfly pea over 119 ha in Nov 2005, 4 kg/ha perennial grasses over 135 ha in Dec 2006	
Fertiliser	3.3 kg P/ha over 119 ha in Nov 2005	
Rainfall	648 mm	442 mm
Average butterfly pea green leaf	21.5% CP, 67% DMD	
Average butterfly pea biomass	143 kg DM/ha	302 kg DM/ha
Average grass biomass	5519 kg DM/ha	4775 kg DM/ha
Average % butterfly pea in diet	3.6% (d 77–261)	9.4% (d 51–362)
Average diet quality	7.5% CP, 59% DMD	8.8% CP, 59% DMD
Cattle production		
Cattle	Mostly steers, 1 group of heifers; ~ 13-38% *B. indicus*; 7 groups ranging from 7 to 24 mths at entry; 1 group: 400 d HGP	
Total grazing days per period	181	223
Average stocking rate	0.29 AE/ha	1.09 AE/ha
Total LWG (total area)	50 kg/ha	245 kg/ha
Economics ($/ha)		
Gross margin—owner rates	17	379
Forage costs	21	21
Gross margin—contract rates	15	377
Forage costs	23	23

Conclusions

- This butterfly pea–grass paddock was monitored towards the end of the expected benefit period of butterfly pea (ca. 10 years) as the paddock was planted to butterfly pea 7–8 years prior to the start of the monitoring period.
- The pasture contained only 4.6% butterfly pea biomass on average (range 0–14.5%).
- Soil P levels were not measured but were expected to have been adequate for maintaining butterfly pea in the pasture, being an alluvial soil.
- The paddock received 6 periods of spelling, totalling 325 days or 45% of the total monitoring period. This grazing management strategy would have assisted in maximising the butterfly pea component of the pasture.
- Cattle were consuming only 7% of the diet as species other than grass. It is assumed that most of this would have been butterfly pea.
- Cattle growth rates from those groups monitored ranged from −0.01 kg/head/day over 79 days from late winter to early spring 2013, to 1.18 kg/head/day over 67 days in autumn 2013.
- Total beef production, averaged over the 2, 12-month periods, was 148 kg/ha/annum.
- Annual, amortised forage costs were low due to the long productive life of the forage.
- Average cattle price margin was $0.05 for the first 12-month period and $0.16 for the second 12-month period.
- The combined result was an average gross margin of $198/ha/annum, over the 2 years of monitoring.

Central Queensland Brigalow—Butterfly pea–grass (2012–13)

Site description & history	
Land & soil type	Heavy clay alluvial; black cracking clay
Paddock history	Cleared in 1950s or 60s, forage sorghum cropping from 1988 to 2000. Butterfly pea sown in Feb 2001. Part of the paddock periodically floods including in Jan 2011
Soil depth & PAWC	120 cm; 240 mm
Soil nutrients (0–10 cm)	P: 59 mg/kg, Organic C: 2.1%,
Total monitoring period	**28/05/12 to 07/06/13**
Total days	**375**
Forage production	
Total grazing area	44 ha
Area planted to butterfly pea	28 ha (64%)
Planting details	10.7 kg/ha butterfly pea
Rainfall	802 mm
Average butterfly pea green leaf	25.8% CP, 69% DMD
Average butterfly pea biomass	1138 kg DM/ha
Average grass biomass	3480 kg DM/ha
Average % butterfly pea in diet	51% (d 302 & 325)
Average diet quality	12.7% CP, 58% DMD (d 302 & 325)
Cattle production	
Cattle	Maiden heifers, mated in Oct 2012 with 15% not conceiving; ~ 100% *B. indicus*; 20 mths at entry
Total grazing days per period	139
Average stocking rate	0.36 AE/ha (total area)
Total LWG	80 kg/ha
Economics	
	Gross margin expressed per total area, forage costs per forage area only; ($/ha)
Gross margin—owner rates	34
Forage costs	21
Gross margin—contract rates	28
Forage costs	31

Conclusions

- This butterfly pea–grass pasture was monitored towards the end of the expected benefit period of butterfly pea (ca. 10 years) as the paddock was planted to butterfly pea 11 years prior to the start of the monitoring period.
- Despite this, the pasture contained an average of 25% butterfly pea biomass (range 13–33%).
- Adequate soil P levels, grazing management with wet season spelling (236 days in this 375-day period) and competitive advantage due to flooding has maintained relatively high butterfly pea composition in the pasture.
- Cattle were consuming 40–63% of the diet as butterfly pea and had corresponding high diet quality, in the range of that measured for leucaena–grass pastures.
- However, total beef production of 80 kg/ha was much lower than that measured for leucaena–grass pastures due to lower average stocking rate and grazing days.
- Growth rates of heifers that did not conceive ranged from –0.43 kg/head/day over 27 days in late autumn 2013, to 1.10 kg/head/day over the prior 30 days in mid autumn.
- Annual, amortised forage costs were low due to the long productive life of the forage.
- Average cattle price margin was negative: –$0.40/kg LW.
- The combined result was an average gross margin for the total grazing area of $34/ha/annum for the 375 days of monitoring.

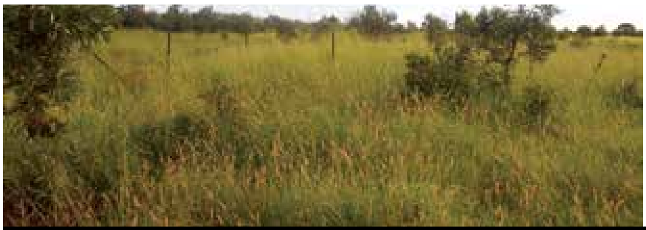
Central Queensland Open Downs—Perennial grass (2011–14)

Site description & history			
Land & soil type	Open Downs; black cracking clay		
Paddock history	Wheat cropped until 2003, then prepared with cultivation & chemical application for aerial grass seeding in 2004		
Soil depth & PAWC	90 cm; 180 mm		
Soil nutrients (0–10 cm)	Nitrate N: 1 mg/kg, P: 7 mg/kg, Organic C: 0.98%, Cl: 19 mg/kg		
Total monitoring period	**22/12/11 to 21/12/12**	**22/12/12 to 16/12/13**	**17/12/13 to 12/02/14**
Total days	**365**	**359**	**57**
Forage production			
Total grazing area	1022.5 ha		
Planting details	2004; 3.5 kg/ha; Gayndah & Biloela buffel, Bisset creeping bluegrass, Bambatsi panic, Katambora Rhodes, silk/sugardrip sorghum		
Rainfall	729 mm	491 mm	185 mm
Average pasture biomass	4549 kg DM/ha	3819 kg DM/ha	4409 kg DM/ha
Average % C_3 in diet	16% (d 267–302)	11% (d 32–343)	8% (d 4–58)
Average diet quality	7.0% CP, 57% DMD (d 267–302)	5.6% CP, 57% DMD (d 32–343)	8.9% CP, 60% DMD (d 4–58)
Cattle production			
Cattle	Steers; 13–38% *B. indicus*; 2 groups, 20–24 mths and 5–12 mths at entry; 2nd group: 400 d HGP		
Total grazing days	157	193	57
Average stocking rate	0.17 AE/ha	0.15 AE/ha	0.35 AE/ha
Total LWG	31 kg/ha/annum	41 kg/ha/annum	13 kg/ha/57 days
Economics ($/ha)			
Gross margin	25	51	Not applicable

Conclusions

- This paddock had been used for grain cropping in the past. It was cultivated and sown with introduced perennial grass species in 2004.
- However, the paddock now consists of 53% native perennial grass species, primarily Queensland bluegrass (48% of the biomass), indicating the pasture is 'run-down' and would benefit from the inclusion of a legume.
- Soil P levels were below that required by introduced legumes suitable for this clay soil.
- Native legumes formed 3.3% of the pasture biomass and were selectively grazed by cattle resulting in up to 25% of the diet being legume species (overall average 11.6%).
- Management strategies of conservative stocking rates and regular spelling (48% of total period of 783 days during the period of monitoring) resulted in relatively high pasture biomass.
- Total beef production, averaged over the 2, full 12-month periods of monitoring, was 36 kg/ha/annum.
- The average cattle price margin was $0.18 and $0.11/kg LW for the 1st and 2nd 12-month periods, respectively.
- The average gross margin, over the 2, full 12-month periods of monitoring, was $38/ha/annum.

Central Queensland Brigalow—Perennial grass (2012–13)

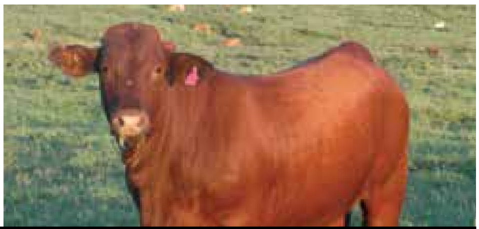


Site description & history			
Land & soil type	Brigalow; brown cracking clay (with melonholes)		
Paddock history	Cleared in 1980s, blade ploughed and perennial grass and legume species sown in 1990s; regrowth cleared in mid 2000s		
Soil depth & PAWC	120 cm; 180 mm		
Soil nutrients (0–10 cm)	P: 28 mg/kg, Organic C: 1.3%		
Total monitoring period	**10/01/12 to 30/04/13**		
Total days	**476**		
Forage production			
Total grazing area	84.5 ha		
Planting details	Perennial grasses (green panic, buffel) & legume (butterfly pea) in 1990s		
Rainfall	1026 mm		
Average pasture biomass	4285 kg DM/ha		
Average % C_3 in diet	9% (d 25–444)		
Average diet quality	6.9% CP, 54% DMD (d 25–444)		
Cattle production			
Cattle	Steers; 100% *B. indicus*; 12–16 mths at entry		
Total grazing days	476		
Average stocking rate	0.64 AE/ha		
Total LWG	138 kg/ha/476 days		
Economics			
	Total period: 476 days($/ha)	If sold prior to compensatory gain: 402 days ($/ha)	If sold at onset of dry period in Aug 2012: 205 days ($/ha)
Gross margin	132	44	42

Conclusions

- During the period of monitoring the dominant pasture species in the paddock were the introduced perennial grasses buffel, sabi and green panic (31%, 24% and 21% of the biomass, respectively), although some Indian bluegrass (3.7%; an increaser species) and native perennial grasses (largely Queensland bluegrass (6.4%)) were present. Legumes formed only 0.14% of the biomass (0.03% butterfly pea, 0.11% native legumes).
- The paddock was continuously grazed at a relatively high stocking rate for perennial grass pasture of 0.64 AE/ha.
- Drought conditions for much of 2012 (2012 rainfall total 470 mm) then extremely high rainfall for last 4 mths of grazing (557 mm).
- Cattle growth rates ranged from 0.06 kg/head/day over 197 days from Aug 2012 to mid Feb 2013, to 1.13 kg/head/day over the following 2 periods of 37 days, each after significant rainfall events. The average liveweight gain over 476 days of grazing was 0.47 kg/head/day.
- The resulting total beef production was 85 kg/ha for the first 12 months but 138 kg/ha for the total 476 days which includes significant compensatory growth following the high rainfall totals in early 2013.
- The cattle price margin as negative: –$0.24/kg LW.
- The combined result was a gross margin for the 476-day period of $132/ha.
- This gross margin was 3 times greater than that expected if the cattle had been sold in early August at the onset of the dry period (after 205 days of grazing) or if the cattle had been sold just prior to the rainfall and compensatory gain effect (after 405 days of grazing). However, the effect on pasture sustainability of very high stocking rates used long-term, along with the high economic risk of holding finishing cattle over an extended dry period, should be considered.

South Queensland Brigalow—Perennial grass (2011–14)

Site description & history			
Land & soil type	Brigalow; brown cracking clay		
Paddock history	Cleared in 1978, burnt in 1979, re-pulled in 1999 & 2009. Paddock stick-racked and heaps burnt in 2009. Blade ploughing of 30 ha in 2009 and 2013		
Soil depth & PAWC	120 cm; 160 mm		
Soil nutrients (0–10 cm)	Nitrate N: 2.6 mg/kg, P: 22 mg/kg, Organic C: 2.5%, Cl: 35 mg/kg		
Total monitoring period	**06/07/11 to 04/07/12**	**05/07/12 to 03/07/13**	**04/07/13 to 17/03/14**
Total days	**364**	**365**	**256**
Forage production			
Total grazing area	304.6 ha		
Rainfall	595 mm	474 mm	204 mm
Average pasture biomass	3673 kg DM/ha	2186 kg DM/ha	2371 kg DM/ha
Average % C_3 in diet	9% (d 22–365)	Not applicable	8% (d 2–257)
Average diet quality	6.9% CP, 53% DMD	Not applicable	5.0% CP, 55% DMD
Cattle production			
Cattle	Heifers & steers; ~25% *B. indicus*; 3 groups, 6–17 mths at entry	Paddock spelled	Steers; ~25% *B. indicus*; 3 groups, 8–14 mths at entry
Grazing days	296	0	206
Average stocking rate	0.87 AE/ha	0 AE/ha	0.55 AE/ha
Total LWG	169 kg/ha	0 kg/ha	64 kg/ha
Economics ($/ha)			
Gross margin	285	–5	–12
Forage costs	5	5	5

Conclusions

- Buffel grass was not deliberately introduced to this paddock but naturalised over time. During the period of monitoring the paddock consisted of primarily buffel grass (97% of the biomass).
- The average pasture biomass was lower than levels measured for the Central Queensland Open Downs and the Central Queensland Brigalow regions and is likely due to pasture 'run-down'
- The paddock was spelled for the entire 2nd, 12-month period of monitoring.
- Average stocking rate was very high during the 1st, 12-month period. However, when stocking rates are averaged over the 2, full 12-month periods of monitoring the value of 0.44 AE/ha is much closer to what is considered long-term sustainable figures for this land type (0.33 AE/ha).
- Cattle growth rates ranged from 0.08 kg/head/day over 80 days from end Jul to mid Oct 2013, to 0.96 kg/head/day over 62 days from mid Jan to mid Mar 2014.
- The costs of blade ploughing the entire paddock every 20 years were accounted for as forage costs.
- The cattle price margin for the first 12-month period was $0.13/kg LW.
- The gross margin averaged over the 2, full 12-month periods was $140/ha/annum.
- The cattle price margin for the final 8.4 month period of monitoring was $0.01/kg LW.
- The gross margin for the final 8.4 months of monitoring was –$12/ha/256 days.

Appendix 1: Assumptions for the example gross margins presented in Chapter 7

A description of each of the example sites and the general assumptions used in the gross margin analysis presented in Chapter 7 are detailed in Tables 14–16. In particular, the following points should be remembered when perusing the tables and considering the results of the gross margin analysis:

- Cattle production from each of the forage types was assessed by comparing the scenario of steers finished to the same target weight (596 kg liveweight; 310 kg carcass weight).
- The grazing days, stocking rate and daily liveweight gain for each forage at each site were based on an assessment of measured values in both unpublished and published reports and the considered judgement of experienced beef research and extension staff.
- These values are based on the assumption that forages are grown and grazed using best-practice agronomic management and represent the expected long-term average performance over both good and bad rainfall years.
- The gross margin analyses were conducted using the assumption that the same market conditions occur across all forages in each region and the results compare the economic performance of the forages based on the defined set of market assumptions.
    - Livestock purchase prices were taken from long-term averages at the Gracemere (Central Queensland Open Downs and Central Queensland Brigalow) or Roma (South Queensland Brigalow) saleyards.
    - The livestock purchase prices used reflect the value of animals (based on weight and age) at the point of entry onto the forage.
    - Livestock sale prices were taken from the long-term averages at the Dinmore meat processing plant.
    - Freight costs were based on 2010 rates from major carriers in each of the relevant regions.
    - Animal health costs were based on 2010 prices.
    - Animal health costs were based on treatments required immediately prior to, or during, forage grazing.
    - For simplicity, forage preparation and planting costs were based on the property owning the machinery. However, the sample spreadsheets provided with this guide also calculate forage costs and associated gross margins on basis of contractors being used to plant the forage.

All terms and abbreviations used in the tables are given at the start of this guide.

Table 14. Central Queensland Open Downs (Emerald-Capella area): description and assumptions for gross margin analysis

Factor	Description
General description and assumptions	
Broad land type	Open Downs
Soil type and characteristics	Black vertosol-Orion PAWC: 150 mm Soil depth: 75 cm Base N level: 40 kg N/ha
Cattle enterprise type and target market for comparison across forage types	Finishing steers (approximately 50% *Bos indicus* and 50% *B. taurus* content) for the Jap Ox market specifications to a finishing weight of 596 kg liveweight and 310 carcass weight (assuming dressing percentage is 52%)
Place of cattle purchase	Gracemere saleyards
Place of cattle sale	Rockhampton meatworks
Perennial grass pasture	
Pasture characteristics	Native pasture, primarily Queensland bluegrass
Stocking rate	0.17 AE/ha (1 AE: 6 ha)
Feeding period for economic analysis	Weaning to turn-off
Assumptions to determine time to turn off steers at target weight	Join breeders on 1st Dec for three months; 318 days from joining to mean calving date; mean calving weight: 35 kg, LWG from birth to weaning: 0.9 kg/head/day; wean on 1st May at 6.5 months and 213 kg
Long-term, steer LWG: Annual Summer (D-J-F) Autumn (M-A-M) Winter (J-J-A) Spring (S-O-N)	139 kg/head/year (0.38 kg/head/day) 0.77 kg/head/day 0.34 kg/head/day 0.11 kg/head/day 0.34 kg/head/day
Calculated grazing days from weaning to turn-off	1006
Age at turn-off	40 months
Animal health treatments	5-in-1 × 1 (booster at weaning)
Forage oats	
Sowing window	1 April to 1 June
Sowing rate	40 kg/ha
Fertiliser	40 kg N/ha applied pre-plant with air-seeder
Fallow weed control	Amicide 625 0.75 L/ha × 2, Glyphosate 450 CT 1.5 L/ha × 2; chisel plough × 1, scarifier × 1
In-crop weed control	MCPA LVE 1 L/ha × 1 application
Planter	Air-seeder, twin bin, spear points and presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	76
Starting cattle weight (kg)	512
LWG (kg/head/day)	1.1
Stocking rate	2.0 AE/ha
Animal health treatments	5-in-1 × 1
Forage sorghum	
Sowing window	1 September to 31 January
Sowing rate	4 kg/ha
Fertiliser	40 kg N/ha applied pre-plant with air-seeder
Fallow weed control	Amicide 625 0.75 L/ha × 2, Glyphosate 450 CT 1.5 L/ha × 2; chisel plough × 1, scarifier × 1
In-crop weed control	Atrazine 3 L/ha × 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels

Factor	Description
Grazing days on forage	130
Starting cattle weight (kg)	518
LWG (kg/head/day)	0.6
Stocking rate	3.0 AE/ha
Animal health treatments	5-in-1 × 1
Lablab	
Sowing window	1 September – 31 January
Sowing rate	25 kg/ha
Fallow weed control	Amicide 625 0.75 L/ha x 2, Glyphosate 450 CT 1.5 L/ha x 2; chisel plough x 1, scarifier x 1
In-crop weed control	Spinnaker 100 g/ha x 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	100
Starting cattle weight (kg)	516
LWG (kg/head/day)	0.8
Stocking rate	2.3 AE/ha
Animal health treatments	5-in-1 x 1
Leucaena–grass	
Assumed life of the forage	30 years
Adjustment to account for time-lag in production after planting	Year of planting: no production; year following planting: grazing days were halved but SR and LWG kept constant
Sowing window	1 January – 31 March
Sowing rate	2.5 kg/ha leucaena; 4 kg/ha tropical grass species
Fertiliser and maintenance	At sowing: 60 kg MAP/ha; maintenance (every 10 years): 100 kg MAP/ha, mechanical cutting
Fallow weed control	Amicide 625 0.50 L/ha x 3, Roundup CT 1.5 L/ha x 3, chisel plough x 1
In-crop weed control	Spinnaker 140 g/ha x 1 and Roundup 1.5 L/ha x 1 application over ½ the area post-plant, pre-emerge
Leucaena planter	Leucaena planter (precision row crop planter)
Grass planter	Drum seeder (at the same time as planting leucaena)
Grazing days on forage	270
Starting cattle weight (kg)	353
LWG (kg/head/day)	0.9
Stocking rate over 365 days	0.44 AE/ha
Animal health treatments	5-in-1 x 1; inoculate 10% of the herd at the rate of 100 mL leucaena rumen fluid inoculum/steer
Butterfly pea–grass	
Assumed life of the forage	5 years
Adjustment to account for time-lag in production after planting	In the year of planting the grazing days were halved but SR and LWG kept constant
Sowing window	15 December – 15 March
Sowing rate	10 kg/ha Milgarra; 2 kg/ha tropical grass species
Fallow weed control	Amicide 625 0.50 L/ha x 3, Roundup CT 1.5 L/ha x 3; Chisel plough x 2, scarifier x 1
In-crop weed control	Spinnaker 150 g/ha x 1 application post-plant, pre-emerge
Butterfly pea planter	Air–seeder, twin bin, spear points with presswheels
Grass planter	Drum seeder (grass planted 12 months later)
Grazing days on forage	270
Starting cattle weight (kg)	421
LWG (kg/head/day)	0.65
Stocking rate over 365 days	0.59 AE/ha
Animal health treatments	5-in-1 x 1

Table 15. Central Queensland Brigalow (Biloela-Rolleston area): description and assumptions for gross margin analysis

Factor	Description
General description and assumptions	
Broad land type	Brigalow
Soil type and characteristics	Grey vertosol PAWC: 137 mm Soil depth: 150 cm Base N level: 60 kg N/ha
Cattle enterprise type and target market for comparison across forage types	Finishing steers (approximately 40% *Bos indicus* and 60% *B. taurus* content) for the Jap Ox market specifications to a finishing weight of 596 kg liveweight and 310 carcass weight (assuming dressing percentage is 52%)
Place of cattle purchase	Gracemere saleyards
Place of cattle sale	Biloela meatworks
Baseline pasture	
Pasture characteristics	Buffel grass (older pastures), minimal tree regrowth
Stocking rate	0.33 AE/ha (1 AE : 3 ha)
Feeding period for economic analysis	Weaning to turn-off
Assumptions to determine time to turn off steers at target weight	Join breeders on 1 Dec for 3 months; 318 days from joining to mean calving date; mean calving weight: 35 kg, LWG from birth to weaning: 0.9 kg/head/day; wean on 1 May at 6.5 months and 213 kg
Long-term, steer LWG: Annual Summer (D-J-F) Autumn (M-A-M) Winter (J-J-A) Spring (S-O-N)	157 kg/head/year (0.43 kg/head/day) 0.84 kg/head/day 0.38 kg/head/day 0.24 kg/head/day 0.38 kg/head/day
Calculated grazing days from weaning to turn-off	891
Age at turn-off	36 months
Animal health treatments	5-in-1 × 1 (booster at weaning)
Forage oats	
Sowing window	1 April to 1 June
Sowing rate	40 kg/ha
Fertiliser	0 kg N/ha
Fallow weed control	Amicide 625 0.75 L/ha × 2, Glyphosate 450 CT 1.5 L/ha × 2; chisel plough × 1, scarifier × 1
In-crop weed control	MCPA LVE 1 L/ha × 1 application
Planter	Air-seeder, twin bin, spear points and presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	83
Starting cattle weight (kg)	505
LWG (kg/head/day)	1.1
Stocking rate (total area)	1.8 AE/ha
Animal health treatments	5-in-1 × 1
Forage sorghum	
Sowing window	1 September to 31 January
Sowing rate	4 kg/ha
Fertiliser	0 kg N/ha
Fallow weed control	Amicide 625 0.75 L/ha × 2, Glyphosate 450 CT 1.5 L/ha × 2; chisel plough × 1, scarifier × 1
In-crop weed control	Atrazine 3 L/ha × 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels
Grazing days on forage	120

Factor	Description
Starting cattle weight (kg)	524
LWG (kg/head/day)	0.6
Stocking rate	3.0 AE/ha
Animal health treatments	5-in-1 × 1
Lablab	
Sowing window	1 September to 31 January
Sowing rate	25 kg/ha
Fallow weed control	Amicide 625 0.75 L/ha × 2, Glyphosate 450 CT 1.5 L/ha × 2; chisel plough × 1, scarifier × 1
In-crop weed control	Spinnaker 100 g/ha × 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	100
Starting cattle weight (kg)	516
LWG (kg/head/day)	0.8
Stocking rate	2.3 AE/ha
Animal health treatments	5-in-1 × 1
Leucaena–grass	
Assumed life of the forage	30 years
Adjustment to account for time-lag in production after planting	Year of planting: no production; year following planting: grazing days were halved but SR and LWG kept constant
Sowing window	1 January to 15 March
Sowing rate	2.5 kg/ha Leucaena; 4 kg/ha tropical grass species
Fertiliser and maintenance	At sowing: 60 kg MAP/ha; maintenance (every 10 years): 100 kg MAP/ha, mechanical cutting
Fallow weed control	Amicide 625 0.50 L/ha × 3, Roundup CT 1.5 L/ha × 3; chisel plough × 1
In-crop weed control	Spinnaker 140 g/ha × 1 and Roundup 1.5 L/ha × 1 application over ½ the area post-plant, pre-emerge
Leucaena planter	Leucaena planter (precision row crop planter)
Grass planter	Drum seeder (at the same time as planting leucaena)
Grazing days on forage	270
Starting cattle weight (kg)	353
LWG (kg/head/day)	0.9
Stocking rate over 365 days	0.44 AE/ha
Animal health treatments	5-in-1 × 1; inoculate 10% of the herd at the rate of 100 mL leucaena rumen fluid inoculum/steer
Butterfly pea–grass	
Assumed life of the forage	5 years
Adjustment to account for time-lag in production after planting	In the year of planting the grazing days were halved but SR and LWG kept constant
Sowing window	15 December to 28 February
Sowing rate	10 kg/ha Milgarra; 2 kg/ha tropical grass species
Fallow weed control	Amicide 625 0.50 L/ha × 3, Roundup CT 1.5 L/ha × 3; chisel plough × 2, scarifier × 1
In-crop weed control	Spinnaker 150 g/ha × 1 application post-plant, pre-emerge
Butterfly pea planter	Air-seeder, twin bin, spear points with presswheels
Grass planter	Drum seeder (grass planted 12 months later)
Grazing days on forage	250
Starting cattle weight (kg)	446
LWG (kg/head/day)	0.6
Stocking rate over 365 days	0.55 AE/ha
Animal health treatments	5-in-1 × 1

Table 16. South Queensland Brigalow (Taroom–Wandoan area): description and assumptions for gross margin analysis

Factor	Description
General description and assumptions	
Broad land type	Brigalow
Soil type and characteristics	Grey vertosol PAWC: 162 mm Soil depth: 150 cm Base N level: 50 kg N/ha (soil has 'run-down' in N levels due to a greater number of years of cropping and/or planting to buffel pasture relative to Central Queensland Brigalow)
Cattle enterprise type and target market for comparison across forage types	Finishing steers (approximately 40% Bos indicus and 60% B. taurus content) for the Jap Ox market specifications to a finishing weight of 596 kg liveweight and 310 kg carcass weight (assuming dressing percentage is 52%).
Place of cattle purchase	Roma saleyards
Place of cattle sale	Dinmore
Baseline pasture	
Pasture characteristics	Buffel grass (older pastures); minimal tree regrowth
Stocking rate	0.33 AE/ha (1 AE : 3 ha)
Feeding period for economic analysis	Weaning to turn-off
Assumptions to determine time to turn off steers at target weight	Join breeders on 1 Nov for 3 months; 318 days from joining to mean calving date; mean calving weight: 35 kg, LWG from birth to weaning: 0.9 kg/head/day; wean on 1 May at 7.5 months and 240 kg
Long-term steer LWG: Annual Summer (D-J-F) Autumn (M-A-M) Winter (J-J-A) Spring (S-O-N)	149 kg/head/year (0.41 kg/head/day) 0.77 kg/head/day 0.34 kg/head/day 0.22 kg/head/day 0.42 kg/head/day
Calculated grazing days from weaning to turn-off	870
Age at turn-off	36 months
Animal health treatments	5-in-1 x 1 (booster at weaning)
Forage oats	
Sowing window	1 April – 1 June
Sowing rate	40 kg/ha
Fertiliser	20 kg N/ha applied at planting
Fallow weed control	Amicide 625 0.75 L/ha x 2, Glyphosate 450 CT 1.5 L/ha x 2; chisel plough x 1, scarifier x 1
In-crop weed control	MCPA LVE 1 L/ha x 1 application
Planter	Air-seeder, twin bin, spear points and presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	90
Starting cattle weight (kg)	497
LWG (kg/head/day)	1.1
Stocking rate	2.3 AE/ha
Animal health treatments	5-in-1 x 1
Forage sorghum	
Sowing window	20 October – 31 January
Sowing rate	4 kg/ha
Fertiliser	20 kg N/ha applied at planting
Fallow weed control	Amicide 625 0.75 L/ha x 2, glyphosate 450 CT 1.5 L/ha x 2; chisel plough x 1, scarifier x 1
In-crop weed control	Atrazine 3 L/ha x 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels
Grazing days on forage	130

Factor	Description
Starting cattle weight (kg)	525
LWG (kg/head/day)	0.55
Stocking rate	2.5 AE/ha
Animal health treatments	5-in-1 x 1
Lablab	
Sowing window	15 October – 31 January
Sowing rate	25 kg/ha
Fallow weed control	Amicide 625 0.75 L/ha x 2, glyphosate 450 CT 1.5 L/ha x 2, chisel plough x 1; scarifier x 1
In-crop weed control	Spinnaker 100 g/ha x 1 application post-plant, pre-emerge
Planter	Air-seeder, twin bin, spear points with presswheels
% of the paddock sown to forage	90% of total grazing area
Grazing days on forage	90
Starting cattle weight (kg)	524
LWG (kg/head/day)	0.8
Stocking rate	2.3 AE/ha
Animal health treatments	5-in-1 x 1
Leucaena–grass	
Assumed life of the orage	30 years
Adjustment to account for time-lag in production after planting	Year of planting: no production; year following planting: grazing days were halved but SR and LWG kept constant
Sowing window	1 January – 28 February
Sowing rate	2.5 kg/ha leucaena; 4 kg/ha tropical grass species
Fertiliser and maintenance	At sowing: 60 kg MAP/ha; maintenance (every 10 years): 100 kg MAP/ha, mechanical cutting
Fallow weed control	Amicide 625 0.5 L/ha x 3, Roundup CT 1.5 L/ha x 3; chisel plough x 1
In-crop weed control	Spinnaker 140 g/ha x 1 and Roundup 1.5 L/ha x 1 over ½ the area post-plant, pre-emerge
Leucaena planter	Leucaena planter (precision row crop planter)
Grass planter	Drum seeder (at the same time as planting leucaena)
Grazing days on forage	240
Starting cattle weight (kg)	380
LWG (kg/head/day)	0.9
Stocking rate over 365 days	0.36 AE/ha
Animal health treatments	5-in-1 x 1; inoculate 10% of the herd at the rate of 100 mL leucaena rumen fluid inoculum/steer
Butterfly pea–grass	
Assumed life of forage	5 years
Adjustment to account for time-lag in production after planting	In the year of planting the grazing days were halved but SR and LWG kept constant
Sowing window	15 December – 15 February
Sowing rate	10 kg/ha Milgarra; 2 kg/ha tropical grass species
Fallow weed control	Amicide 625 0.5 L/ha x 3, Roundup CT 1.5 L/ha x 3; chisel plough x 2 scarifier x 1
In-crop weed control	Spinnaker 150 g/ha x 1 application post-plant, pre-emerge
Butterfly pea planter	Air–seeder, twin bin, spear points with presswheels
Grass planter	Drum seeder (grass planted 12 months later)
Grazing days on forage	240
Starting cattle weight (kg)	452
LWG (kg/head/day)	0.6
Stocking rate over 365 days	0.53 AE/ha
Animal health treatments	5-in-1 x 1

The ‘High Output Forages’ team members present at one of the project field days.

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