APPENDIX 1.

The MLA Feed Demand Calculator for the Border Rivers and Maranoa-Balonne regions – **a report on the compilation of standard data to be included.**

<u>APPENDIX 1</u>. The MLA Feed Demand Calculator for the Border Rivers and Maranoa-Balonne regions – **a report on the compilation of standard data to be included**

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1. Summary

The MLA Feed Demand calculator (FDC) is a useful tool to improve feed year planning and the strategic management of livestock demand and feed supply. However, this tool has not been parameterised to be used in subtropical regions of southern Queensland and northern New South Wales. In particular, the need to include a variety of forage sources (including grass pastures, and summer and winter growing forage crops) and variability in pasture growth were identified as key development requirements. The APSIM model was used to simulate monthly growth rates for 6 common forage species in average, high and low yielding years at 4 locations across the region. The quality of pasture consumed through the year was then estimated from these growth rates, and assumptions of utilisation and quality of pasture components of various ages. This report documents the rationale, methodologies used and results that were obtained during these processes. Overall these simulations and estimations were considered to accurately represent experience of forage growth rate and quality in the region and will be incorporated as standard data in the software. Nonetheless there remains the capacity for users to enter their own data or adjust the provided data according to their situation.

2. Background

As part of the "More Beef from Pastures" program, MLA has produced a spreadsheet-based tool to compare feed supply and animal demand on a property in various high rainfall regions of southern Australia (the "MLA feed demand calculator"). For each month of the year, the FDC calculates the total feed demand of all livestock on a property and compares the total demand to the likely supply of pasture. Feed supply is calculated from monthly pasture growth curves – default values are provided or actual values can be used, while demand is calculated from live-weight change and diet digestibility as the weight of pasture needed to provide for the range of grazing animals on the property. This is a useful tool for 'feed year planning' or investigating strategic decisions about improving the match of the requirements of the livestock enterprise and forage supply.

While this tool would be useful in the Border Rivers and Maranoa-Balonne regions in southern Queensland and northern NSW, the existing version required substantial changes to make it suitable for these subtropical systems.

3. Development requirements for a northern FDC

The following modifications to the FDC were identified to make it suitable for the Border Rivers and Maranoa-Balonne regions.

1. *Locations* - Previously the most northern region was the North-west slopes and Upper Hunter of NSW. Four new locations were chosen in the Border Rivers and Maronoa-Balonne regions to cover spatial variation in pasture growing conditions - Warialda, Goondiwindi, Roma and St George.
2. *Pastures* - A variety of pasture and forage types are available to contribute to the whole-farm feedbase in the subtropical regions. A better combination of these was a priority of the Grain and Graze projects in the region. Six pasture types or feed sources (all dryland) were identified as priorities that are commonly used:
    a. native/naturalised pasture

   b. sown tropical perennial grass pasture
   c. summer-growing legume (e.g. lablab)
   d. lucerne
   e. oats
   f. forage sorghum

   The MLA Feed demand calculator was configured to integrate these various forage sources into a single feed supply curve for the whole farm.

3. *Pasture quality* - In addition to pasture growth rates, pasture quality (energy or digestibility) also needed to be determined for each of the various subtropical pastures and forages to be included.

4. *Reliability* - The southern FDC only used one average pasture growth curve for a region. Given the greater seasonal variation in rainfall and pasture growth in the subtropical Grain & Graze regions, compared to high rainfall southern systems, some measure of this variation also needed to be included.

4. Simulation of pasture/forage growth rates

4.1 Methods

Simulation modelling was used to generate long-term average monthly pasture growth curves for the 6 forage and pasture species based on 100 years of historical meteorological data at each of the 4 locations. Modules available in APSIM version 5.3 were used to simulate lablab, oats, forage sorghum (sweet sorghum) and lucerne, and APSIM-Grasp was used to simulate a naturalised grass pasture. APSIM-Grasp was tested against the recommended ‘Cedar’ form of the GRASP (Grass Production) model to ensure reasonable agreement against an available dataset and for long-term simulations of seasonal growth and standing DM from the two models for at Brigalow Research Station (Fig. 1 & 2)

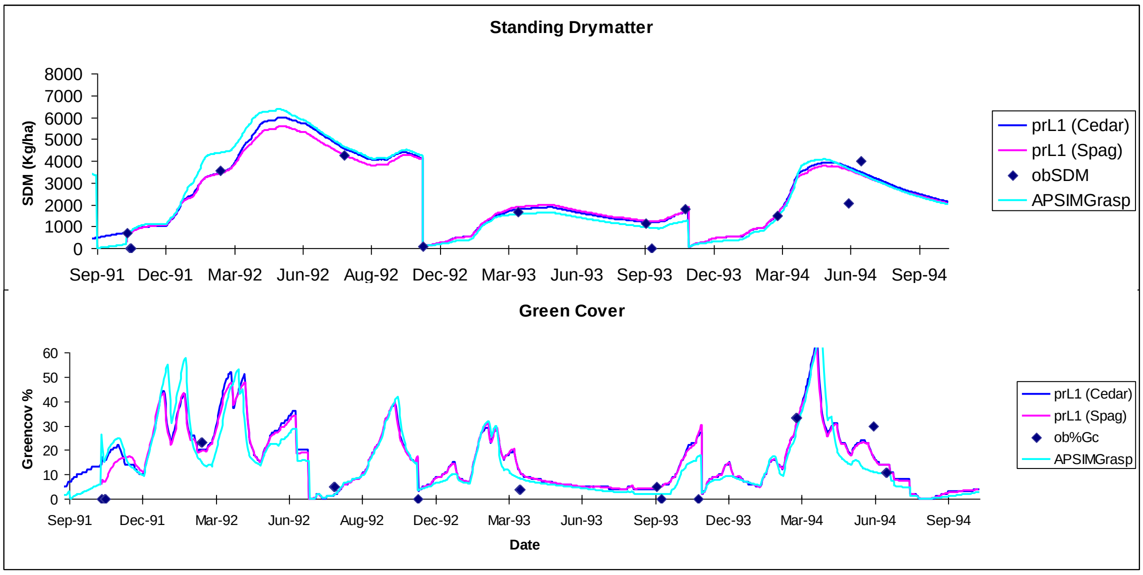


Figure 1. Comparison of APSIM-Grasp and forms of GRASP with collected data of standing DM and green cover at Brigalow Research Station.

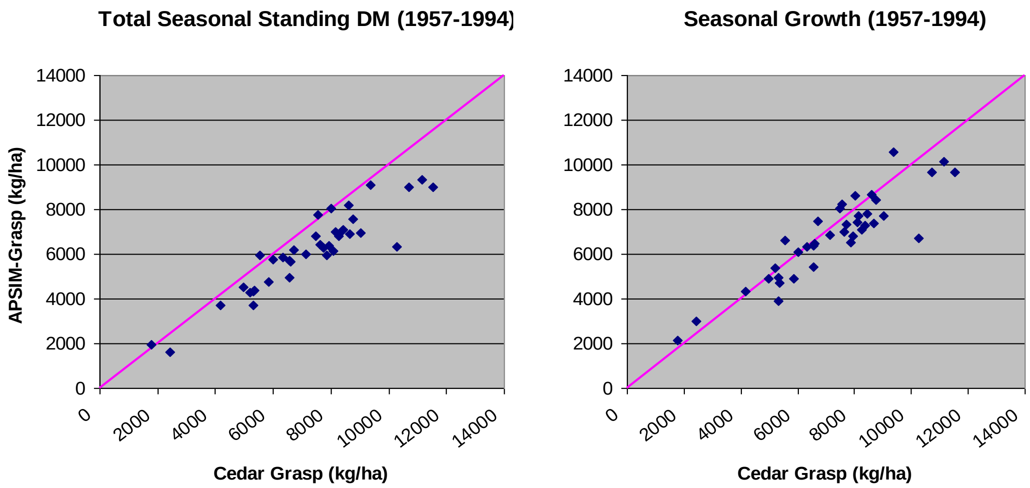


Figure 2. Agreement between simulated total seasonal standing DM and seasonal growth from APSIM-Grasp and Cedar GRASP models.

A grey vertosol, Brigalow/Belah soil parameterised to a depth of 2.4 m was used for all forages and pastures (Fig. 3). The total soil plant available water capacity (PAWC) for each forage species is shown in Table 1. Users of the calculator should note that the growth rates may vary according to different soil water characteristics, nitrogen fertilities and combinations of these. The MLA Feed Demand Calculator is not intended to handle these environmental variations, but some testing has shown that forage growth rates under the simulated scenarios are similar across a range of soil types, provided similar levels of nitrogen are available.

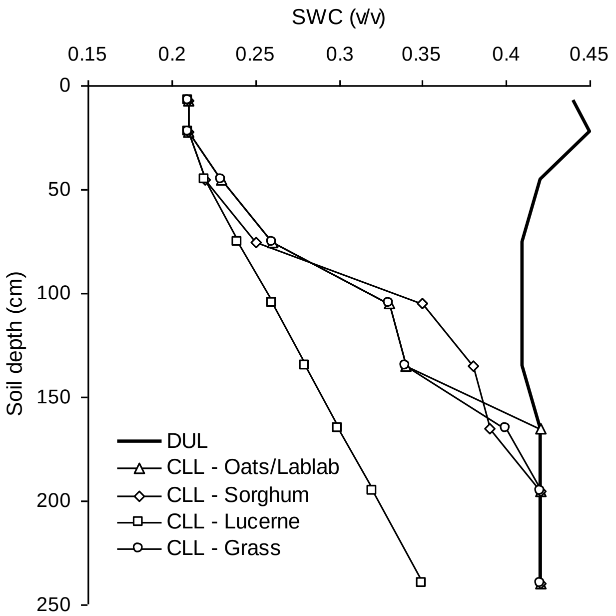


Figure 3. Drained upper limit (DUL) and crop lower limits (CLL) for the grey vertosol soil used in simulations of pastures and forages.

The lucerne and grass pasture were established only once at the start of the simulation and allowed to equilibrate before data were included. Plant numbers were maintained throughout the simulation. No soil resets were included for lucerne, but for the grass pasture soil N and OM was reset annually on the 1 August.

Table 1. Simulation details of soil water characteristics and cutting management.

Crop	Cultivar	Soil PAWC (mm)	Soil reset	Cutting management	
				Timing	Height
Lablab	*Highworth*	217	Crop end	Floral initiation or > 3 t DM/ha	10 cm
Oats	*Coolibah*	217	Crop end	Flowering or > 3 t DM/ha	10 cm
Forage sorghum	*Sugargraze*	214	Crop end	Flowering or > 80 cm height	15 cm
Lucerne	*Trifecta*	373	Nil	Flowering or > 2.0 t DM/ha	5 cm
Grass pasture		196	1 Aug	30% green DM each month	

Each of the annual forage crops were sown each year using a variable sowing rule which required 20 mm of rainfall over 3 days and 60 mm of plant available soil water (PASW) before the crop was sown (Table 2). If these criteria were not met, the crop was sown on the final day of the sowing window (Table 2). Growth of the summer growing annual crops ended on the date of the first frost and for oats on the 1 December each year (Table 2). Soil water was reset to crop lower limit and standard soil nitrogen content (64 kg N/ha) at the date the crop was removed for each of the annual forage crops and the paddock remained fallow during the non-growing season.

Table 2. Annual forage crop sowing and crop end criteria and management.

Crop	Sowing window[A]	Rainfall	Min PASW (mm)	Plants/m^2	Fertiliser (kg N/ha)	Crop end criteria
Lablab	20 Oct – 15 Dec	20 mm over 3 days	60	10	Nil	Min temp < 5^{o}C
Oats	1 Apr – 1 Jul	20 mm over 3 days	60	100	80	1 Dec
Forage sorghum	20 Oct – 15 Dec	20 mm over 3 days	60	20	100	Min temp < 5^{o}C

[A] Sowing occurred on the last date if other criteria had not been met previously

The capacity to simulate grazing of crops is still under development in APSIM, thus cutting was used to mimic grazing for each of the crops. The cutting management used is presented in Table 1. Thus, lablab and oats were cut to a height of 10 cm at floral initiation or when more than 3 t/ha of dry matter had grown. For buffel grass, 30% of the green dry matter present was removed at the end of each month.

As no reliable simulation models were available for a sub-tropical sown grass, growth rates were derived from the simulated native/naturalised pasture values as follows: June-July, same as native pasture; September-November, 20% greater than native pasture; remainder of year 10% greater than native pasture.

Total pasture/forage growth was calculated from the accumulation of daily growth fortnightly, monthly and annually. Average daily growth rate in each month was calculated from 100 years of simulated growth. Initially it was intended that growth rates representing the 25 and 75 percentile for each month would be used to provide for climatic variability in pasture growth. However, it was evident that these grossly under- and over-estimated annual pasture production because years with low yields do not have low growth rates in all months and similarly years with high yields do not have high growth rates in all months. Thus, high and low monthly growth rates were sourced from the average for the 20 years with the highest and lowest annual yield. This closely corresponds with the 10th and 90th percentile of annual production.

Simulated data were compared with published values and assessed by local pasture agronomists to ensure that reasonable simulation management was used and realistic growth rates were obtained.

4.2 Results

Simulated monthly growth rates for native grass pasture, lucerne, lablab, oats, and forage sorghum at the 4 locations in the Border Rivers and Maranoa-Balonne regions are shown in Figures 4-8. In general, the lowest growth rates and annual productivity were simulated at St George and the highest at Warialda. The model simulated the expected pattern and magnitude of growth rates well for most species, but the current lucerne model simulated unusually even growth through the year. Annual production and its variations also reflected experience in the region. However, it should be noted that these data represent total annual growth and do not account for senescence, death or detachment of material.

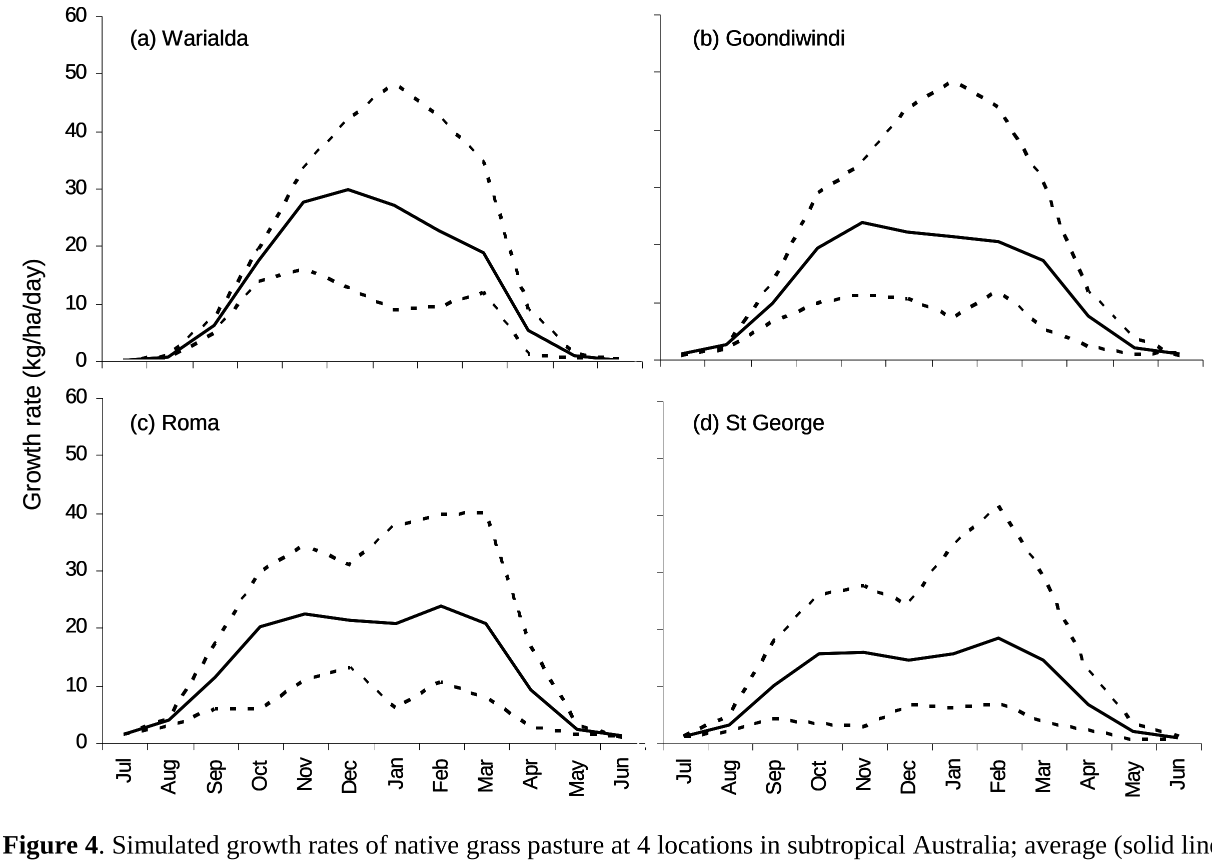


Figure 4. Simulated growth rates of native grass pasture at 4 locations in subtropical Australia; average (solid line) and for the highest and lowest 20% of yielding years (dotted lines).

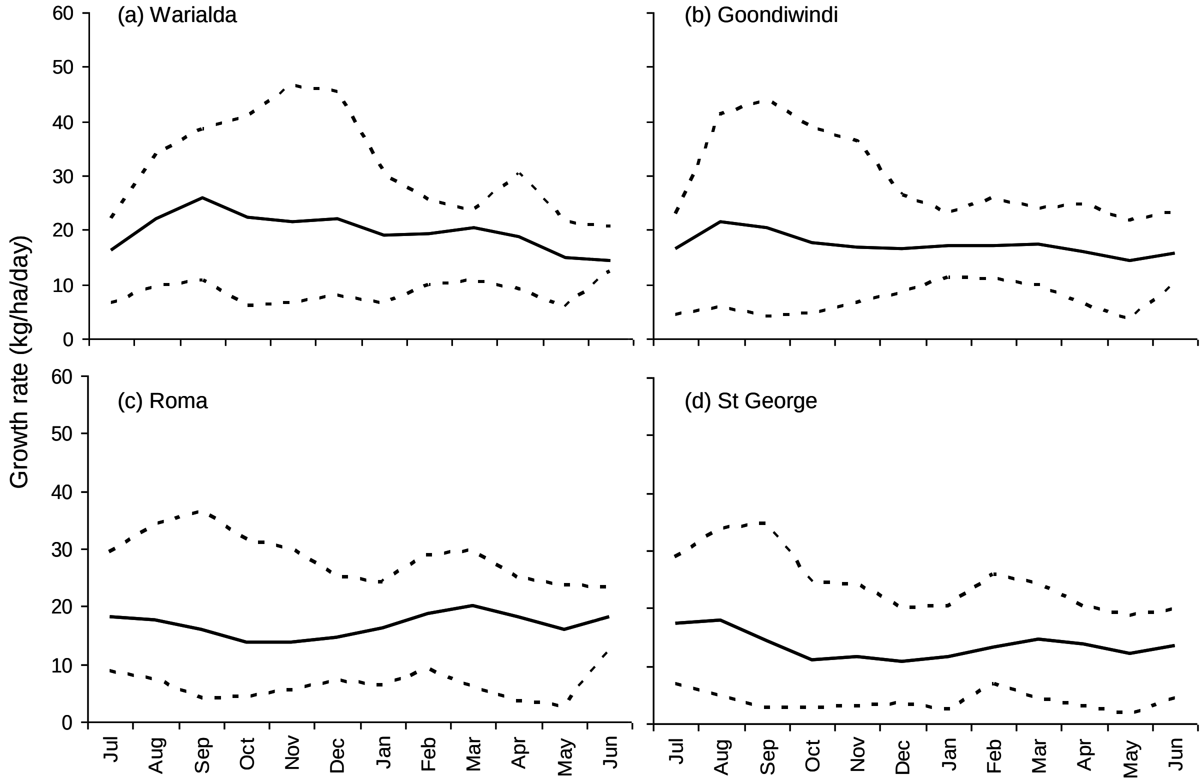


Figure 5. Simulated growth rates of lucerne at 4 locations in subtropical Australia; average (solid line) and for the highest and lowest 20% of yielding years (dotted lines).

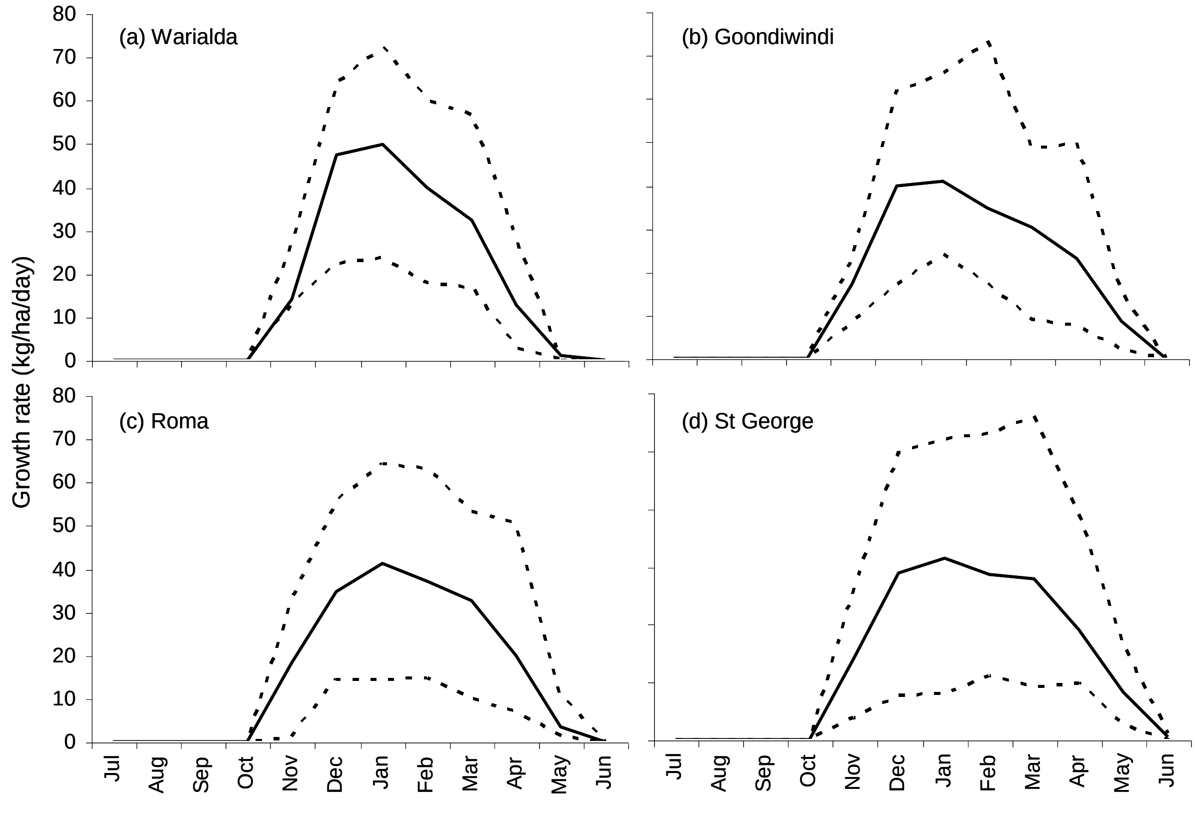


Figure 6. Simulated growth rates of lablab at 4 locations in subtropical Australia; average (solid line) and for the highest and lowest 20% of yielding years (dotted lines).

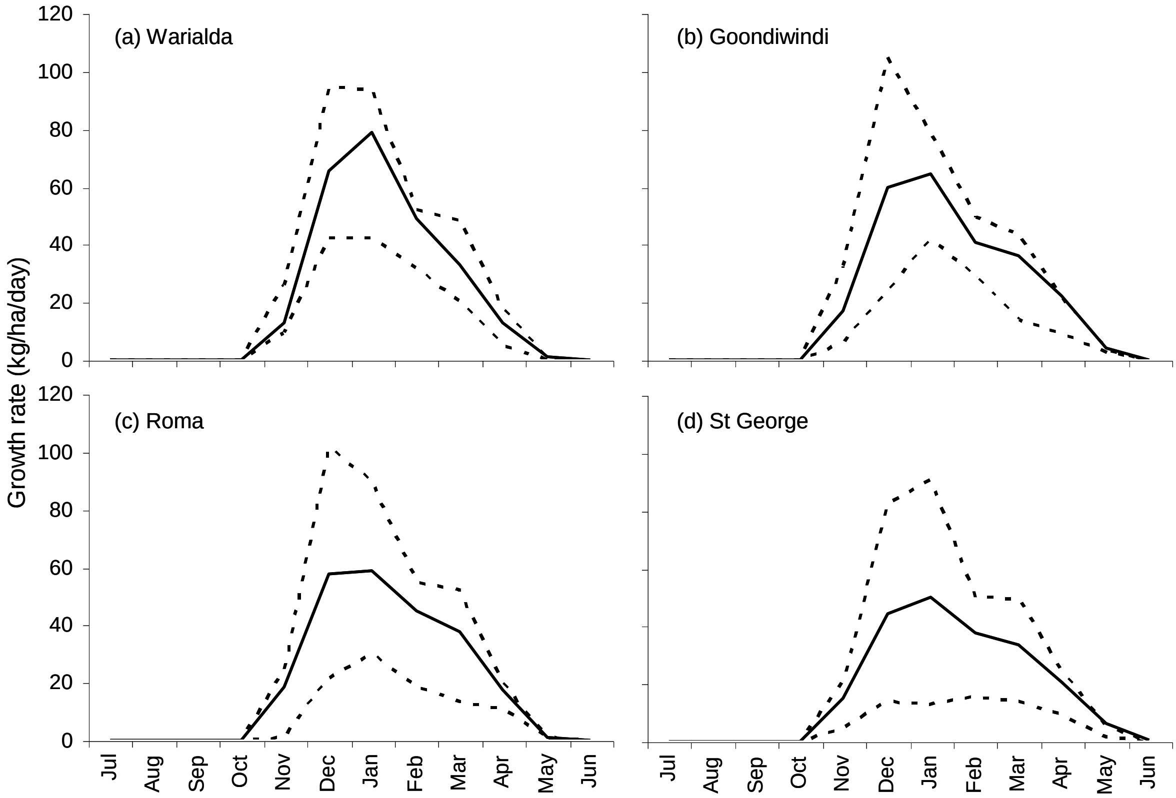


Figure 7. Simulated growth rates of forage sorghum at 4 locations in subtropical Australia; average (solid line) and for the highest and lowest 20% of yielding years (dotted lines).

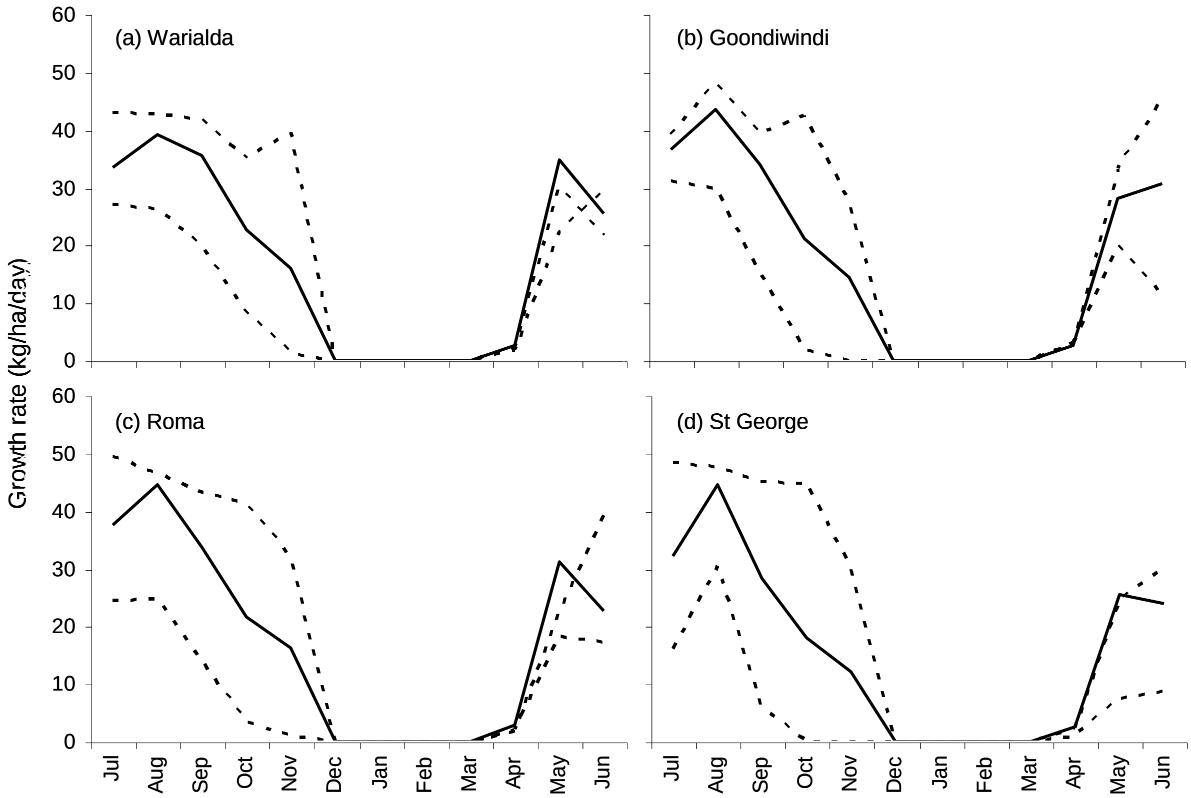


Figure 8. Simulated growth rates of oats at 4 locations in subtropical Australia; average (solid line) and for the highest and lowest 20% of yielding years (dotted lines).

5. Estimation of pasture/forage quality

5.1 Methods

Estimates of the feed quality of the diet consumed by livestock are required for each forage/pasture type in the MLA FDC. There are no consistent values or measurements of herbage quality or dry matter digestibility (DMD) available for all the pasture types so digestibility of the animal diet throughout the year were calculated within a spreadsheet using the following approach. If necessary these can be converted to metabolisable energy concentration (MJ ME/kg DM) where

ME = 0.1604×DMD – 1.037 (Minson, D.J. and McDonald, C.K (1987) Estimating forage intake from the growth of beef cattle. *Tropical Grasslands* **21,** 116-122).

The digestibility of the dry matter intake for various pastures has been calculated as follows:

A) Simulated plant growth was partitioned between leaf and stem in variable proportions during the year (Table 3). Lucerne is assumed to remain vegetative throughout and all new growth is 60% leaf. Grasses allocate most photosynthate to leaves early in the growing season (August) and the allocation declines until March-April (peak flowering/ seed production) and after that the proportion allocated to leaf increases again.

Table 3. Monthly proportion of leaf in new growth of pasture/forage species.

Month	Native pasture & sown grass	Lablab	Forage sorghum	Oats
Aug	80			70
Sep	70			60
Oct	60	60	70	50
Nov	50	50	60	40
Dec	40	40	50	
Jan	35	30	50	
Feb	30	20	50	
Mar	25	15	50	90
Apr	25	15	50	90
May	40	15	50	85
Jun	55			80
Jul	70			75

B) Young plant material is the highest quality, and quality declines as material ages both while it remains green and particularly when it senesces. Green material is divided into five age classes of two weeks each. Leaves and stems were assumed to remain green for ten weeks before senescing. Thus, the 12 classes of plant material were:

GL1 green leaf (1-2 weeks old)
GL2 green leaf (3-4 weeks old)
GL3 green leaf (5-6 weeks old)
GL4 green leaf (7-8 weeks old)
GL5 green leaf (9-10 weeks old)
DL dead leaf (more than ten weeks old)
GS1 green stem (1-2 weeks old)
GS2 green stem (3-4 weeks old)
GS3 green stem (5-6 weeks old)
GS4 green stem (7-8 weeks old)

GS5 green stem (9-10 weeks old)
DS dead stem (more than ten weeks old)

Each of the plant components has a digestibility that is specific to the species, as shown in Table 4.

Table 4. Digestibility values of plant components for each forage/pasture species collated using expert knowledge and data from the literature.

Pasture	Green leaf					Dead leaf	Green stem					Dead stem
	1	2	3	4	5		1	2	3	4	5	
Native pasture	68	63	58	54	50	45	50	49	48	47	46	40
Sown grass	70	65	60	56	52	47	52	50	50	49	48	42
Lablab	71	70	69	67	65	60	65	63	61	59	57	53
Oats	72	68	64	62	60	55	65	62	59	56	53	50
Forage sorghum	70	65	60	56	52	47	52	50	50	49	48	42
Lucerne	72	71	70	69	68	60	67	66	65	64	63	55

C) Simulations of pasture growth rates at 2-weekly intervals were used to estimate the amount of forage grown in the youngest class of plant material in each period (GL1 & GS1). After each two week period material then progressed through to the next oldest category unless it was consumed by livestock. Similarly, the oldest green material (GL5 and GS5) becomes dead material in the next two-week if it is not eaten. If not eaten, dead material was assumed to detach from the plants to become litter at the rate of 10% per half-month.

D) The quality of the diet selected by grazing animals was estimated based on rates of utilisation of annual production for each pasture type (Table 5) and the selection of preferred pasture components. Animals prefer leaf to stem, green to dry, and young to old material. Animals were assumed to select from the pasture components in the following order: GL1 < GL2 < GL3 < GL4 < GL5 < GS1 <GS2 < GS3 < GS4 < GS5 < DL < DS. However, even though they may strongly prefer young green leaf, it is unlikely they will be able to select a diet consisting entirely of green leaf without any other components. Therefore, the maximum amount of any component has been set to 80% of intake and the remaining 20% comes from less preferred components in order of preference. When a desired component is in short supply it is unlikely an animal will be able to harvest all the material even if they wish to. The maximum amount of a component that can be consumed has been set at 80% of the amount of that component that is present.

E) The proportion of each pasture component selected in the diet and their respective digestibility (based on the above assumptions) was then used to calculate the total quality of material consumed by animals for each forage/pasture source throughout a year.

Table 5. Total utilisation of different pasture/forage species.

Pasture	Grazing period	Utilisation (%)
Native pasture	All year	30
Lablab	December-June	70
Oats	May-November	70
Sown grass	All year	40
Forage sorghum	December-May	70
Lucerne	All year	60

5.2 Results

Overall the estimated pasture quality throughout the year seemed to closely match data from the literature and expert opinion. Comparisons of the monthly changes in forage quality between the 6 pasture/forage types are shown in Figure 6. Native pasture was estimated to have a slightly superior digestibility to sown grass pasture in spring – most agronomists would not agree with this as sown grasses grow better than native pastures at this time. The difference is probably a result of the different levels of utilisation – the lower level on the native pasture allows animals to eat a higher proportion of young green leaf.

There was little difference in pasture quality between the three Queensland sites so these have been averaged to provide one value for Queensland; the Warialda values were often different (Fig. 7). For example, digestibility of both grass pastures was slower to increase in spring and fell off faster in autumn to a lower level at Warialda than at the Queensland sites. Lablab and forage sorghum digestibility also decline faster in autumn at Warialda than in Queensland, but there was little or no difference between sites for oats and lucerne.

Using the high, low and average growth rates had little impact on forage quality as the level of utilisation was the same for each. Examples of estimated quality for sown grass and lablab at Roma for low, average and high monthly growth rates are shown in Fig 8. However, this may be an artefact of the methods of calculation and may require further attention. In particular, the calculation method does not consider that pasture growth can vary significantly between months and thus feed excess may decrease the quality of the forage being consumed.

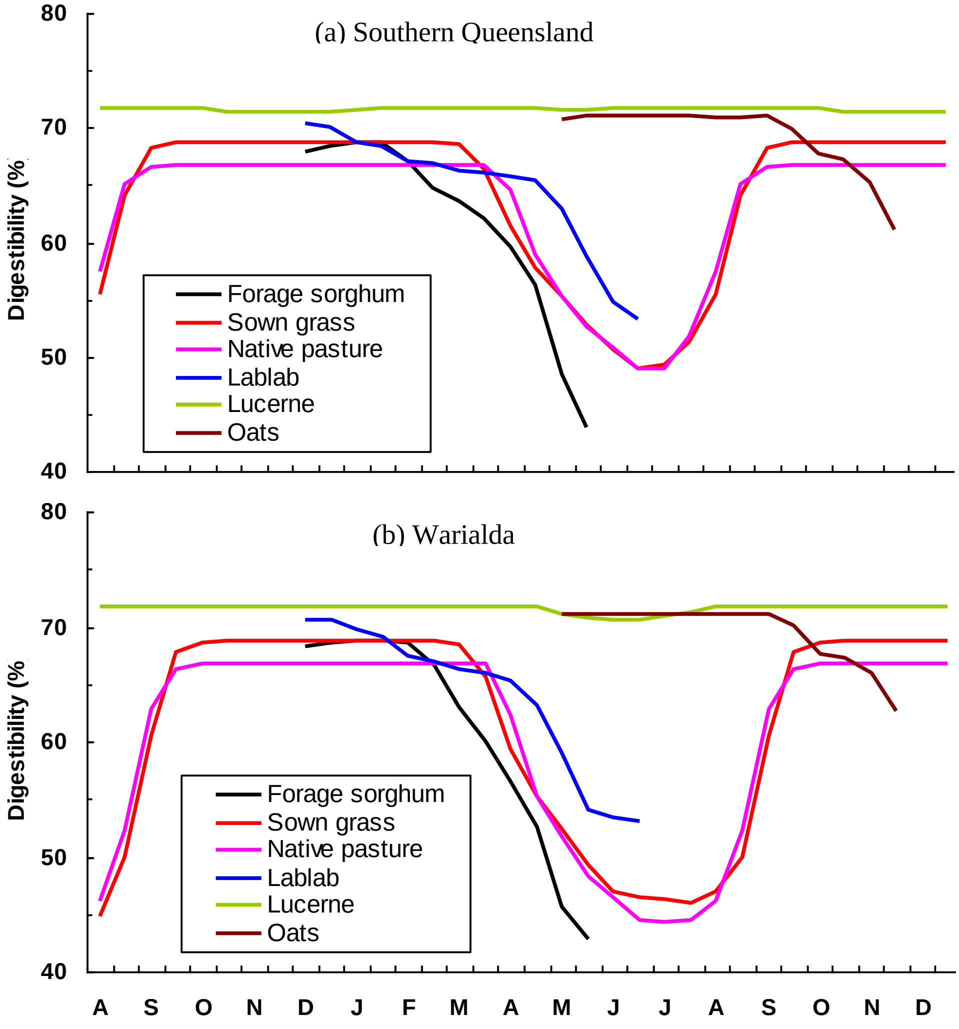


Figure 6. Average monthly digestibility of animal diet grazing various forage sources in (a) southern Queensland and at (b) Warialda.

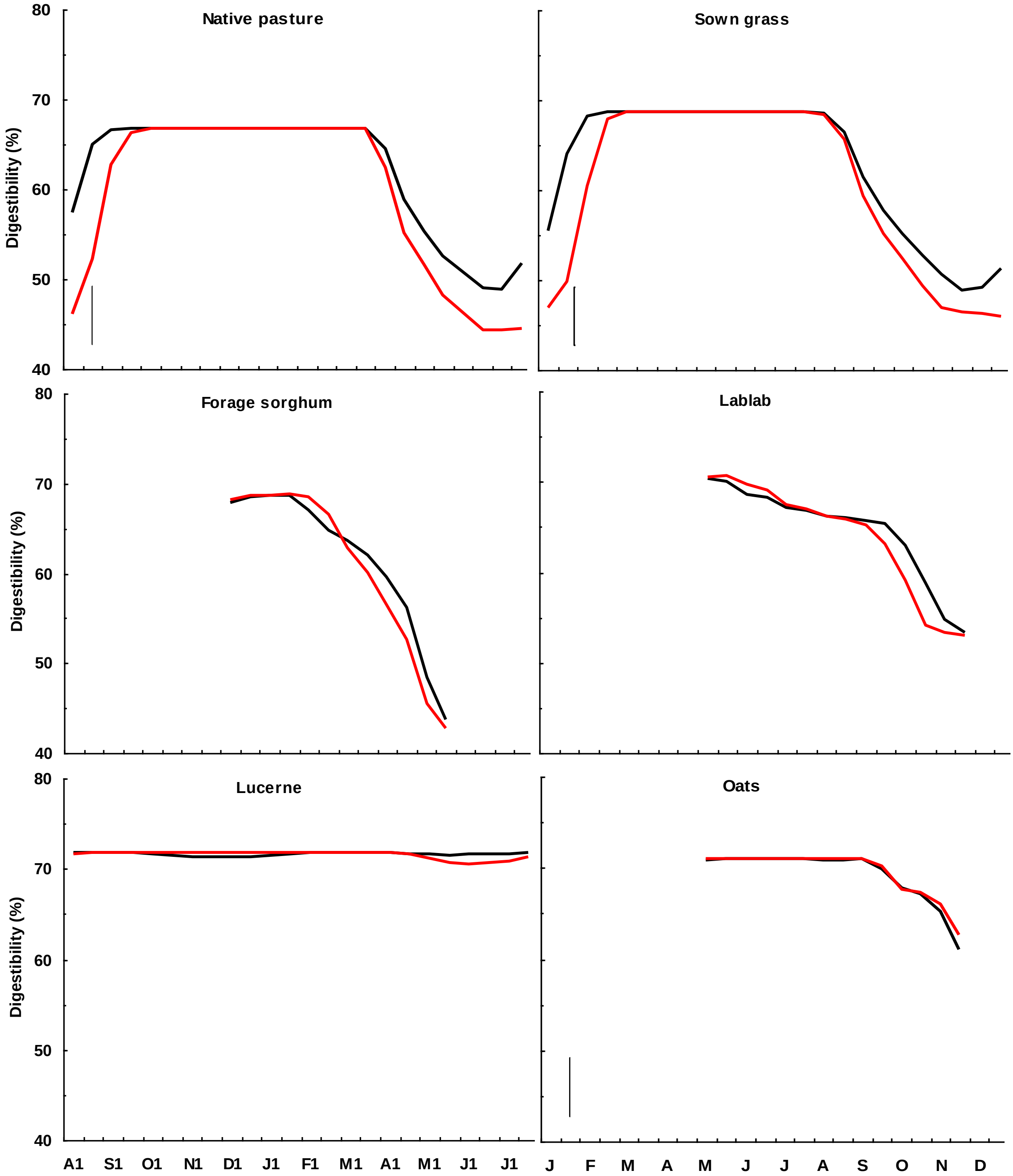


Figure 7. Comparison of estimated forage quality for 6 forage species between southern Queensland sites (black lines) and Warialda (red lines)

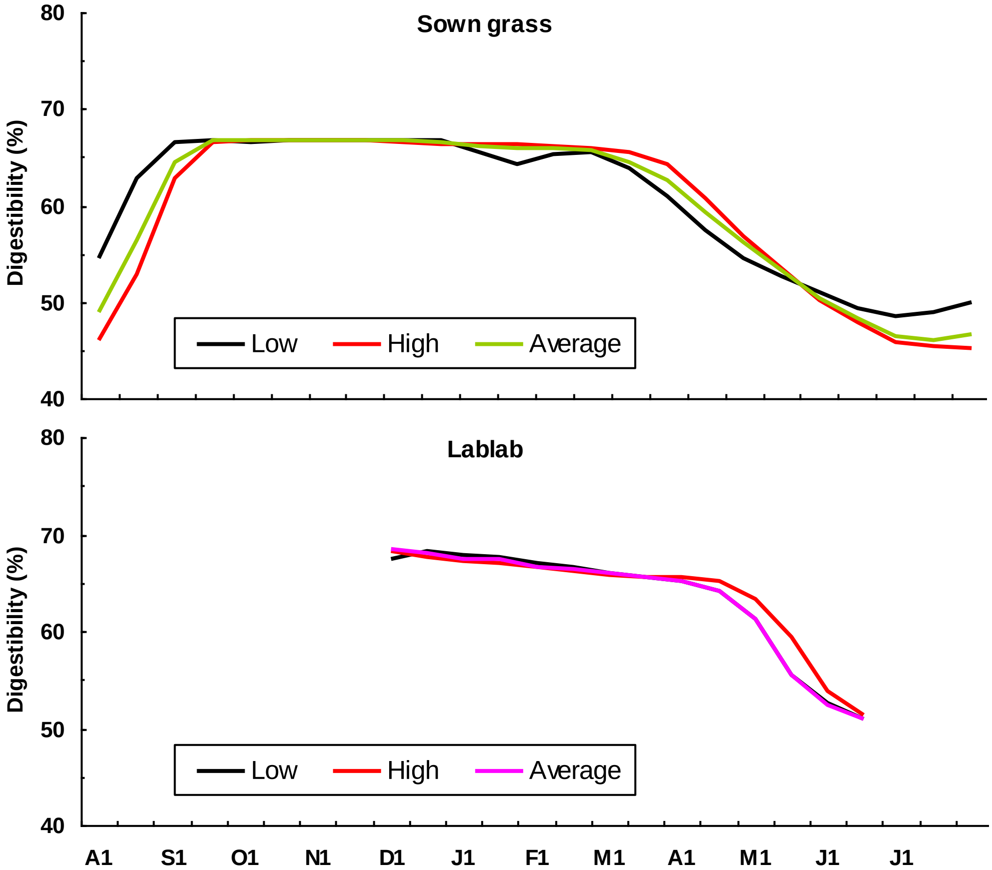


Figure 8. Difference in estimated forage quality calculated for low, high and average monthly growth rates for sown grass and lablab at Roma.

6. Conclusion

Grazing animals on summer growing grass pastures (native and improved) is the foundation for livestock production systems in subtropical southern Queensland and northern NSW. However, there are a range of other forage crops and pastures that are often used. The long-term simulations conducted here provide a useful guide to the annual pattern of growth and quality of these feed sources in these environments and to investigate how combinations of forage sources could be used to improve the continuity of supply and/or to meet livestock demands. The incorporation of growth rates for poor, average and good seasons also enables strategies to manage climate variability to be investigated and evaluated.

Acknowledgments

We thank David Lloyd, Brian Johnson and Trevor Hall, Department of Primary Industry and Fisheries, for their valuable contributions in providing expert opinions on the data generated in this work, and David McNeill for encouragement and assistance with the Feed Demand Calculator.

APPENDIX 2.

FACTSHEET: THE MLA FEED DEMAND CALCULATOR: ***a tool for improving the balance of feed supply and livestock demand.***

APPENDIX 2.

THE MLA FEED DEMAND CALCULATOR: *a tool for improving the balance of feed supply and livestock demand*

The MLA Feed Demand Calculator (FDC) is a simple but useful tool for 'feed year planning' or investigating strategic decisions about improving the match of the requirements of the livestock enterprise and forage supply. Grain and Graze has supported additions to the FDC to make it suitable for use by mixed crop and livestock producers in the sub-tropics. Data was included for growth rates of a number of pastures and forages and locations in the Border Rivers and Maranoa-Balonne regions.

Using the Feed Demand Calculator

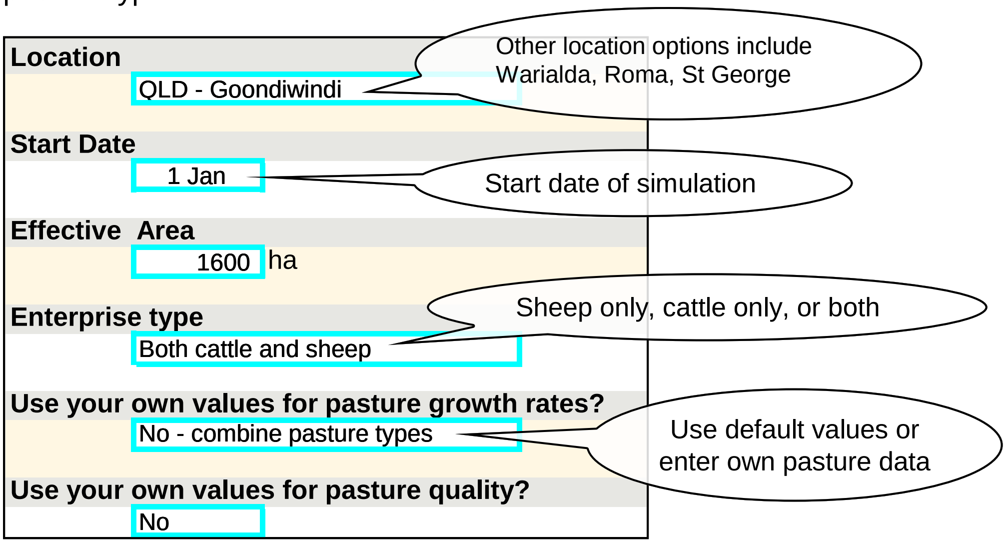
There are three steps to using the FDC.

1. Specify the farms feed-base (i.e., the area of land allocated to different pastures and forage crops)
2. Describe the livestock enterprise i.e. the number and type of animals carried, purchased and sold, and reproductive management
3. Analysing the performance of the system by comparing the feed supply curve to the animal demand through the year.

To gain the greatest benefit from the FDC, these three steps should be repeated looking at scenarios under changed seasonal conditions, and combinations of feed sources and livestock systems.

Step 1. Specifying the farms feed-base

Firstly, it is required to select the most representative location, the date you would like to start the simulation, and the livestock enterprise type to be considered. You are able to input your own values for pasture growth rates and pasture quality, but default data have been included for each pasture type at the chosen location.



Two tables are provided to input the area of each pasture or forage type that is to be included in the farms feed-base. You are also able to select the growth rate for these for an average (standard), good (top 20%) and poor (bottom 20%) year. For the particular year the pasture growth rate and quality for each month, and the total forage produced per hectare and for the entire area grazed are compiled.

Select pasture types and the area (ha) of each type that is available in each month							
Month	Native grass - Standard year	Sown grass - Standard year	Lablab - Standard year	Oats - Standard year	Lucerne - Standard year	Forage sorghum - Standard year	**Total Area (ha)**
Jan	800	500	100	0	50	50	1500
Feb	800	500	100	0	50	50	1500
Mar	800	500	100	200	50	50	1700
Apr	800	500	100	200	50	50	1700
May	800	500	100	200	50	50	1700
Jun	800	500	0	200	50	0	1550
Jul	800	500	0	200	50	0	1550
Aug	800	500	0	200	50	0	1550
Sep	800	500	0	200	50	0	1550
Oct	800	500	100	200	50	50	1700
Nov	800	500	100	200	50	50	1700
Dec	800	500	100	0	50	50	1500

Select the pasture/forage and year type to be included

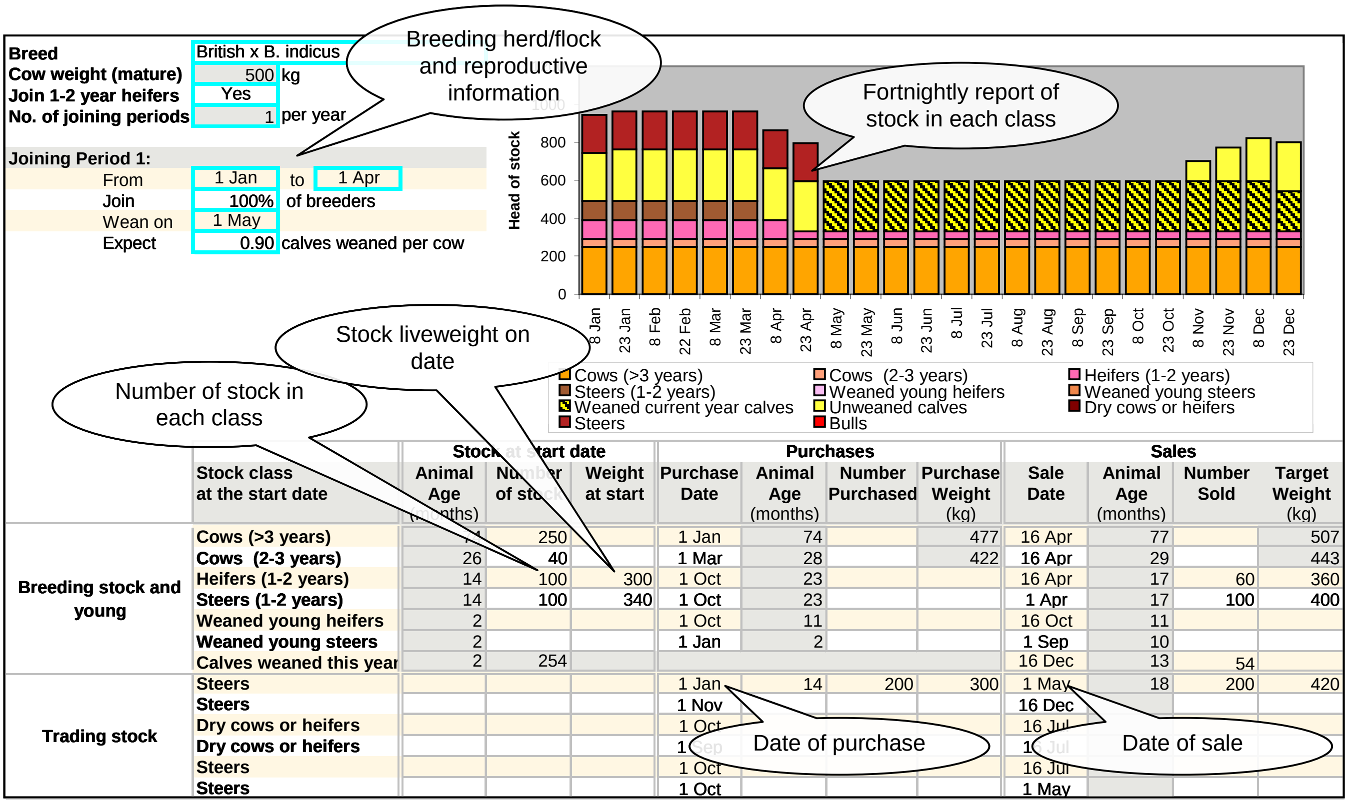
Input the area in hectares of the pasture/forage type

Modify growth rates for each pasture type							
Month	Native grass - Standard year	Sown grass - Standard year	Lablab - Standard year	Oats - Standard year	Lucerne - Standard year	Forage sorghum - Standard year	**Average** (kg/ha/day)
Jan	18	20	41	0	17	64	22
Feb	19	21	35	0	17	40	21
Mar	17	18	30	0	17	36	17
Apr	10	11	23	3	16	22	10
May	3	3	8	28	14	4	7
Jun	1	1	0	31	16	0	5
Jul	1	1	0	37	16	0	6
Aug	2	2	0	44	22	0	8
Sep	7	9	0	34	20	0	12
Oct	17	21	0	21	18	0	17
Nov	21	26	17	15	17	17	21
Dec	21	23	40	0	17	60	24

Typical growth rates are provided for the particular year but can be modified

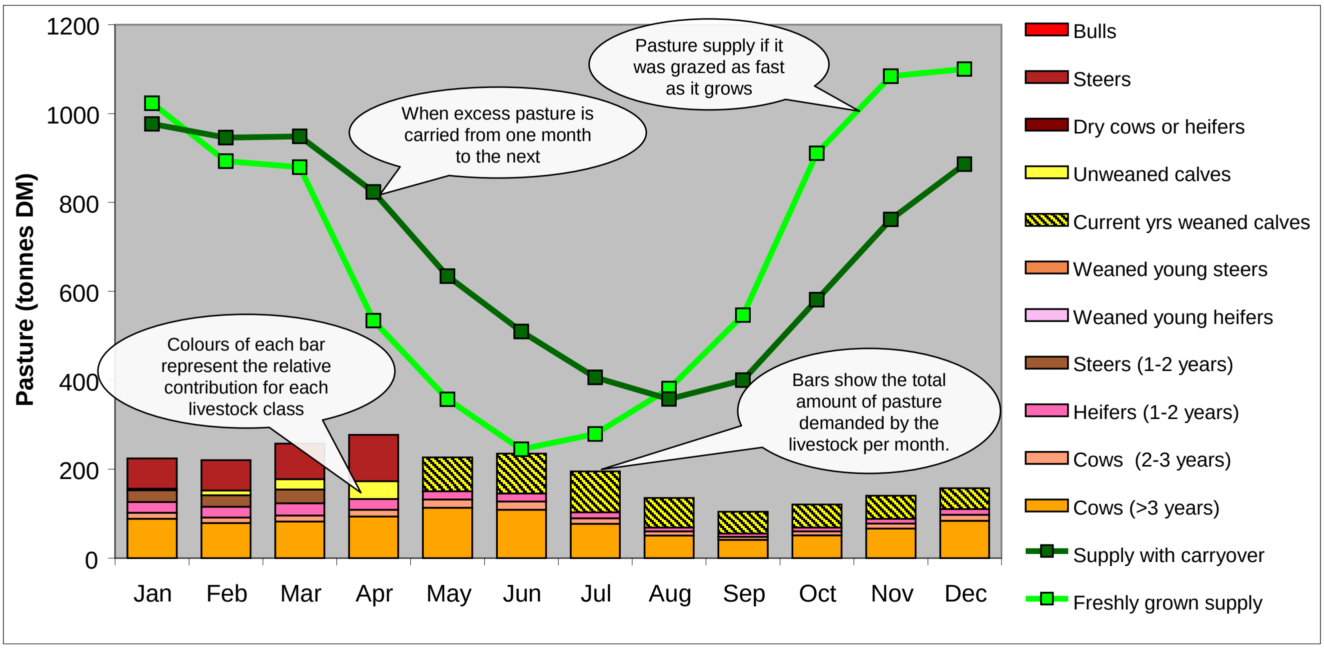
Step 2. Describing the livestock enterprise

For each livestock enterprise (cattle and sheep) details on the structure of the herd or flock are required including the breed, liveweights and number of animals in each stock class, joining and weaning dates, and purchase and sale dates.



Step 3. Analysing the performance of the system

The output provides a graph of the demand profile of the whole herd and/or flock during the 12 months compared to the supply of pasture. Where the tops of the demand bars are higher than the pasture supply curve, there will be insufficient feed for your animals to perform to expectations unless you feed supplements or reduce stock numbers. In the months where the tops of the bars are lower than the pasture supply curve, pasture is in excess.

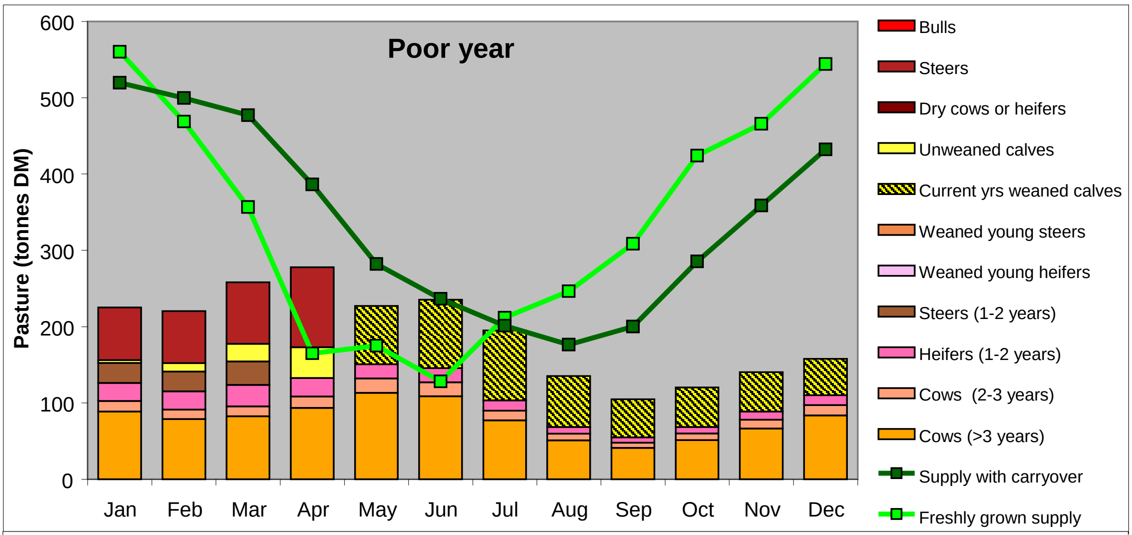


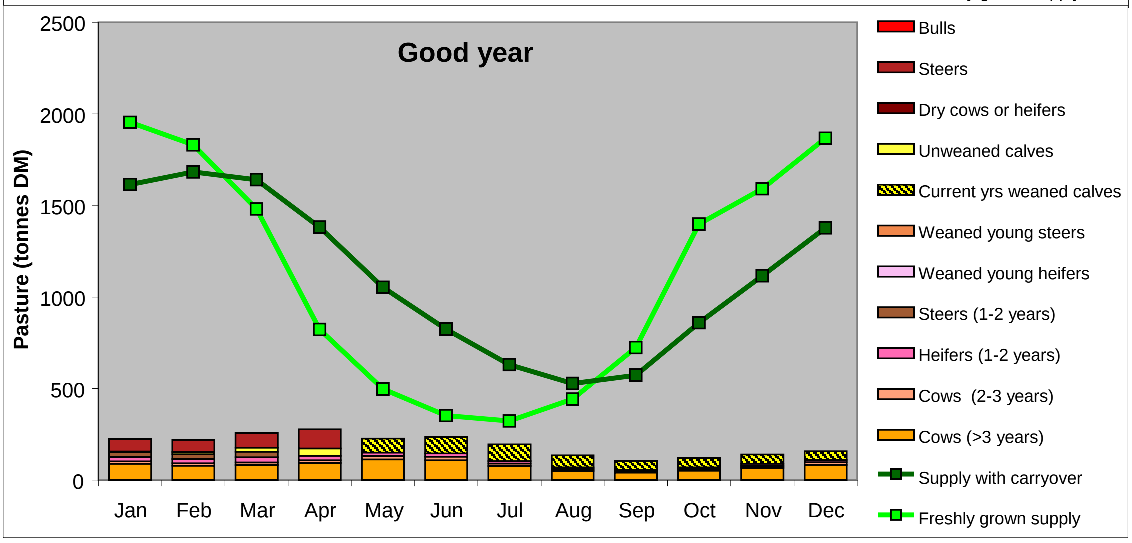
Key performance indicators are summarised for the whole year, such as the extent of the pasture deficit, how many kg of LW produced/ha and the proportion of the total annual pasture grown that was utilised.

Key Performance Indicators		
Pasture deficit, using freshly grown supply	**0**	tonnes/year
Pasture deficit, using supply with carryover	**0**	tonnes/year
Liveweight produced, cattle	**123**	tonnes
Liveweight produced per ha allocated to cattle	**77**	kg/ha/year
Liveweight produced, sheep	**0**	tonnes
Liveweight produced per ha allocated to sheep	**0**	kg/ha/year
Pasture demand as a % of pasture grown	**28**	%

Investigate scenarios

Once the base system has been analysed, investigate some scenarios of how a better match of feed supply and livestock demand might be achieved, such as incorporating another forage source, changing the herd structure or adjusting the joining time. Also analyse the performance of the system in good, average and poor years. For example, the livestock enterprise described above, does not perform as well in a poor season. Options that might be considered here are to sell weaner stock earlier or reduce breeder numbers. In a good season there is a large pasture excess which could be exploited.





To find out more contact

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APPENDIX 3.

Draft report - Simulating the options of sacrificial grazing of crops – wheat in the sub-tropical cereal-growing regions.

APPENDIX 3. Draft report - Simulating the options of sacrificial grazing of crops – wheat in the sub-tropical cereal-growing regions

Lindsay Bell, CSIRO Sustainable Ecosystems, Toowoomba

Aim

This study aimed to investigate the frequency that wheat crops have more value for grazing than for grain production in northern NSW and southern Qld. It was intended to identify circumstances where this commonly occurs and to provide some guidelines on the potential for strategic and tactical use of cereal crops as a forage source.

Method

Simulation approach and assumptions

The APSIM Wheat module was used to predict seasonal variability in wheat biomass and grain production based on 50 years of historical meteorological data. A full factorial was investigated of 12 locations covering the Border Rivers and Maranoa-Balonne regions, 2 common soil types (a grey vertosol with 217 mm of plant available water capacity for wheat (PAWC) and a red brown earth with 140 mm of PAWC), and 8 levels of soil water at sowing (0, 25, 50, 75, 100, 150, 200 mm of total available water and a full soil profile). Specific simulation details were: wheat cv. Hartog was sown on 20 May to achieve 100 plants/m^2; high rates of nitrogen (150 kg N at sowing and 150 kg N at floral initiation) were applied to prevent N stress; and initial levels of soil water, organic matter and mineral nitrogen were reset on the day prior to sowing.

Estimating grazing and grain value

The values of grain and grazing options were estimated from the APSIM outputs for grain yield at harvest and green biomass at floral initiation (67 days after sowing) (Equations 1 and 2). The standard assumptions for grain price were $200 per tonne DW (or $220/tonne at 10% moisture) and harvesting cost of $ 35/ha. Grazing value was calculated based on assumptions of utilization of the wheat crop, livestock production and price. Standard assumptions were a live weight price (LWP) of $1.6/kg LW (approx. current price for yearling trade steers), feed conversion rate (FCR) of 0.1 kg of liveweight/ kg of forage consumed and utilisation rate (U) of 50% of the standing forage. A conservative assumption that only standing biomass at floral initiation was available for grazing and no further growth was included in the standard case. The value of grazing from biomass at flowering was also calculated and compared to this scenario. Since the decision whether or not to graze the wheat crop was taken after sowing, costs for establishing the grain or grazing options were assumed to be equal. Equal transaction and transport costs for grain and livestock were also assumed. Sensitivity analysis of different commodity price scenarios was investigated for the two enterprises.

(1) Grain value ($/ha) = (grain yield × price) – harvesting cost
(2) Grazing value ($/ha) = biomass × U × FCR × LWP

Results

Simulated yields and biomass

As expected across all sites higher levels of available soil water at sowing produced higher average grain yields (Fig. 1). At each level of starting soil water, Warialda produced the highest grain yield and decreasing grain yields were simulated for locations with lower winter rainfall further north and west (Fig. 1). Similar relationships were clear for simulated biomass at floral initiation (not presented). These differences between locations and soil water at sowing are important factors affecting the magnitude of the income that is generated from a crop for grain or grazing purposes. However, Fig. 2 demonstrates that high levels of biomass are not necessarily related to high final grain yields. The relative value of either of these operations is affected by seasonally induced variations in the relationship between crop biomass and grain yield, i.e. if biomass is poorly converted to grain yield, due to frost or drought etc, then grazing a crop may be a better option.

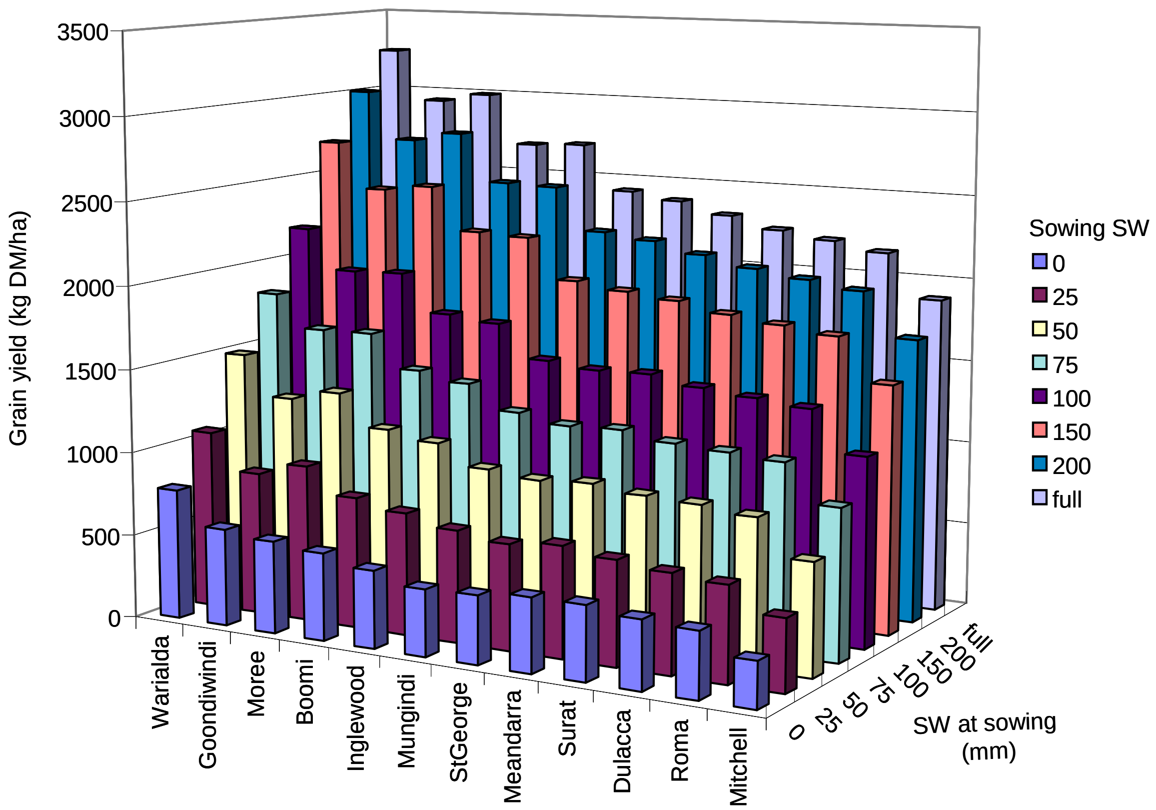

Figure 1. Simulated grain yields of wheat sown at 8 levels of soil water on a grey vertosol at 12 locations throughout northern NSW and southern Queensland wheat-growing region.

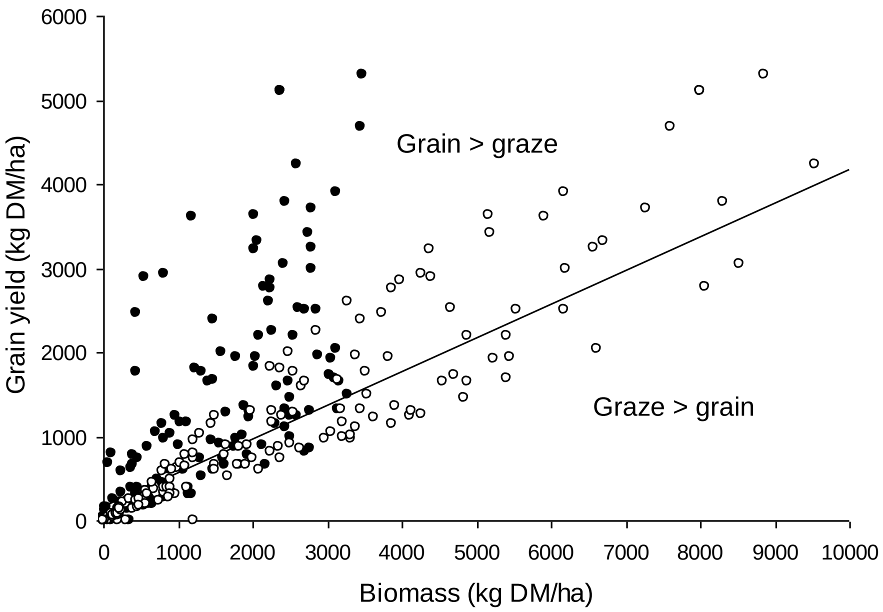

Figure 2. Relationship between crop standing biomass at floral initiation (●) and flowering (○) and final grain yield at Goondiwindi on a grey vertosol soil for ≤ 50 mm available soil water at sowing. Line represents the equal value of biomass for grazing and grain yield under standard price assumptions

Relative grain and grazing value

As expected, with increasing soil water available at sowing the reliability of producing a profitable crop increases and the proportion of years when grazing has more value decreases (Table 1). Among the locations, Warialda had the lowest proportion of years when grazing exceeded grain production, while at all locations in the Maranoa-Balonne region and Mungundi grazing a crop may often exceed its value for grain production (Table 1). At these locations even with 150 mm of total available water in the soil at sowing, approx. 20% of the time (1 in 5 years) grazing a crop is likely to be more profitable than carrying through to harvest. There was also some effect of soil type. At the same total available soil water at sowing, a crop growing on a red earth was more frequently profitable for grazing than one growing on a grey vertosol.

Table 1. The proportion of years that wheat crop biomass at floral initiation has more value for grazing than continuing to grain harvest on a grey vertosol soil at locations throughout the northern grains belt.

		Starting available soil water in profile (mm)							
Region	**Location**	**0**	**25**	**50**	**75**	**100**	**150**	**200**	**full**
Border Rivers	Warialda	0.51	0.41	0.29	0.22	0.18	0.16	0.00	0.00
	Moree	0.65	0.51	0.43	0.29	0.20	0.14	0.06	0.00
	Goondiwindi	0.63	0.51	0.43	0.33	0.24	0.12	0.02	0.00
	Inglewood	0.75	0.51	0.43	0.33	0.27	0.12	0.06	0.00
	Boomi	0.65	0.57	0.47	0.37	0.31	0.16	0.06	0.00
	Mungindi	0.78	0.63	0.57	0.49	0.41	0.22	0.04	0.00
Maranoa -Balonne	Dulacca	0.78	0.71	0.65	0.55	0.49	0.22	0.12	0.00
	Meandarra	0.78	0.65	0.63	0.51	0.39	0.24	0.08	0.00
	Roma	0.82	0.63	0.59	0.47	0.37	0.24	0.12	0.00
	Surat	0.71	0.61	0.55	0.41	0.33	0.25	0.10	0.00

St George	0.80	0.65	0.57	0.51	0.33	0.18	0.06	0.00
Mitchell	0.78	0.71	0.71	0.65	0.59	0.31	0.16	0.00

Table 2. Effect of soil type and starting soil water on the proportion of years that biomass at floral initiation has more value for grazing than continuing to grain harvest (average across all sites).

	Starting available soil water in profile (mm)							
Soil	**0**	**25**	**50**	**75**	**100**	**150**	**200**	**full**
Grey vertosol	0.72	0.59	0.53	0.43	0.34	0.19	0.07	0.00
Red earth	0.75	0.65	0.59	0.52	0.45	0.30	0.18	0.10

While it may be useful to know the proportion of years that a crop might be grazed, it is more practical to understand the critical yield below which a crop has more value to be sacrificed for grazing. For all locations there was a strong linear relationship between final grain yield and the relative value of grain or grazing uses for the crop. Figure 3 demonstrates an example of the relationship for two locations for 50 years of data and a range sowing soil water. Points below the line represent years when grazing is relatively more profitable. The critical grain yield is the point at which grazing and grain have equal value. Interestingly there is little difference in the critical yield among locations or soil types (Table 3). Based on the current commodity prices, 800 kg DM/ha appears to be the grain yield below which grazing a crop is more often profitable.

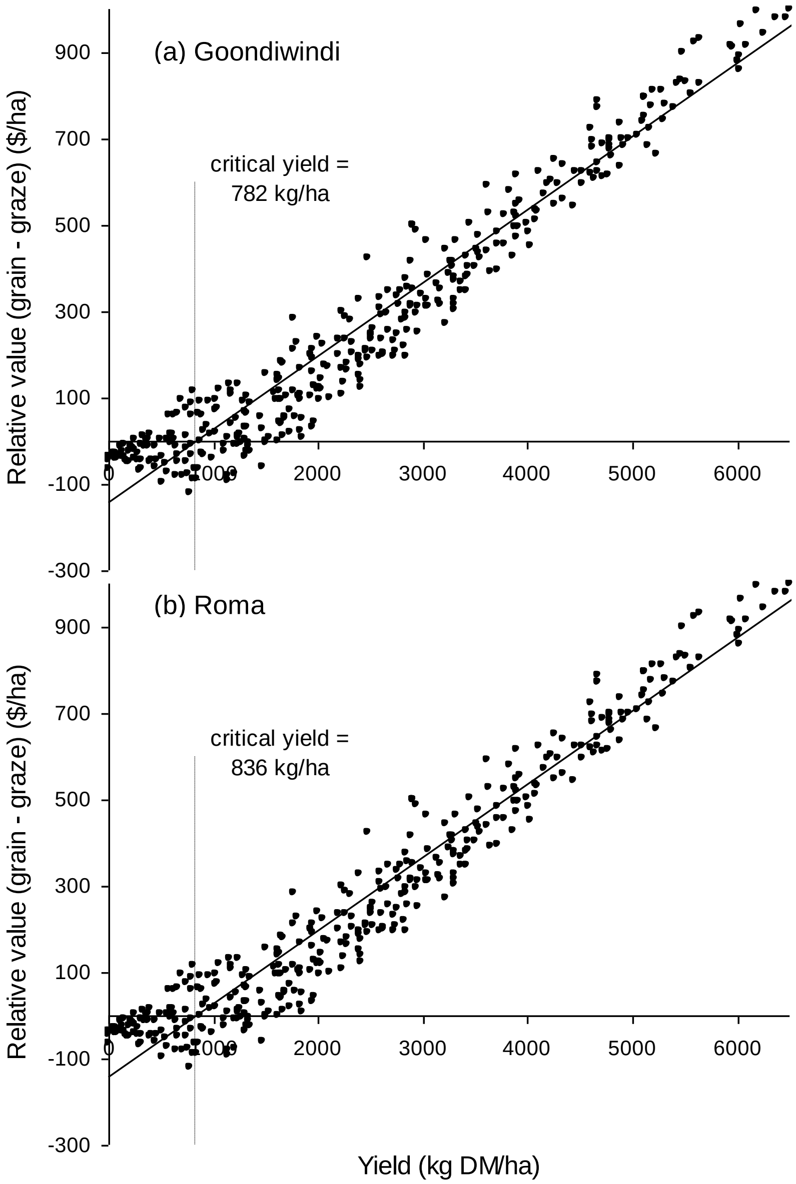

Figure 3. Relationship between grain yield and relative value of grain or grazing the wheat crop at floral initiation at (a) Goondiwindi and (b) Roma on a grey vertosol.

Table 3. Critical yield at a range of locations and soil types throughout the northern grains belt based on current commodity prices

	Soil type	
Location	Red Earth	Grey vertosol
Warialda	827	834
Goondiwindi	782	795
Mungundi	793	797
Dulacca	847	850
Roma	836	839
Mitchell	855	876
All sites (average)	799	796

Commodity price sensitivity

While the comparison of yield of grain and biomass are important, the prices for grain and livestock also have a significant affect on the outcome between the two potential uses. An increase in grain prices relative to livestock price will obviously reduce the proportion of years that grazing is more profitable (Table 4). For example, a change from $200/t to $300/t for grain and a maintained livestock price would halve the number of years that grazing is more profitable at Goondiwindi on a grey vertosol with 50 mm of soil water at sowing. Nonetheless, even with the most advantageous price scenario for grain, a crop sown with 0 mm of soil water is still more often valuable for grazing than for grain production.

Table 4. Effect of grain and livestock price on the proportion of years that biomass at floral initiation has more value for grazing for 0 mm and 50 mm of sowing soil water at Goondiwindi on a grey vertosol. Current price scenario is in bold.

Livestock Price	**Grain Price ($/t DM)**							
	0 mm of sowing soil water				50 mm of sowing soil water			
($/kg LW)	300	250	200	150	300	250	200	150
1	0.53	0.57	0.61	0.63	0.06	0.12	0.25	0.41
1.2	0.55	0.59	0.63	0.63	0.10	0.18	0.33	0.45
1.4	0.57	0.61	0.63	0.65	0.14	0.25	0.39	0.47
1.6	0.57	0.63	**0.63**	0.67	0.20	0.31	**0.43**	0.47
1.8	0.59	0.63	0.63	0.67	0.25	0.39	0.45	0.51
2	0.61	0.63	0.65	0.75	0.29	0.43	0.45	0.63

The critical grain yield for sacrificial grazing of the crop is also sensitive to commodity prices. Using the previous example of an increase in grain price from $200/t to $300/t and the same livestock price, the critical yield would decrease from 800 kg DM/ha to 500 kg DM/ha.

Table 5. Critical yield (kg/ha) below which grazing a crop has more value than harvesting grain under a range of grain and livestock price scenarios across all locations in the northern grains belt. Current price scenario is in bold.

Livestock	**Grain Price ($/t)**			
Price ($/kg LW)	300	250	200	150
1.0	336	411	530	744
1.2	385	473	614	873
1.4	436	539	704	1015
1.6	489	607	**799**	1170
1.8	545	679	901	1341
2.0	602	755	1011	1530

Variations in time of grazing

The standard case presented above assumed that only biomass at floral initiation was available for grazing, but more biomass is available at flowering (Fig. 4). This could be considered in two ways; either this accounts for the additional crop growth that would occur from floral initiation onwards while the crop is being grazed, or if grazing was deferred until flowering this biomass would be available for grazing at this time. In the first case, animal performance and utilisation of the crop might be maintained and would greatly increase the proportion of years that grazing is more profitable (Table 6, standard assumptions). If grazing was deferred until flowering, a reduction in either utilisation or animal performance might be expected due to poorer quality of the forage at this time. A decrease in utilisation of 15% (to 35% of biomass) or a reduction in animal feed conversion by 0.03 kg LW per kg of DM consumed would result in a similar result to the standard case using biomass at floral initiation (Table 6). This suggests that there is flexibility about the timing that grazing is initiated.

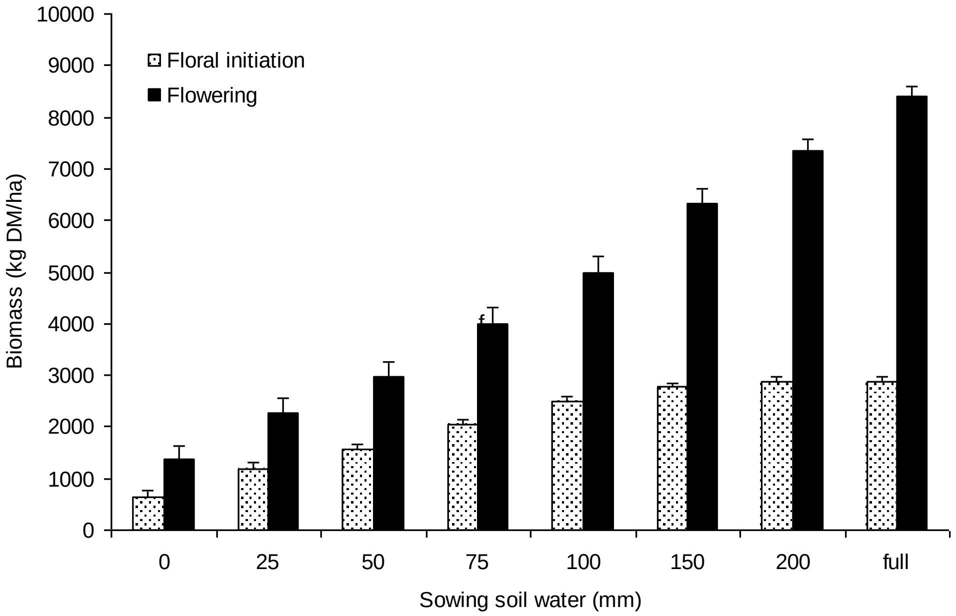

Figure 4. Biomass of wheat crop at floral initiation and flowering at Goondiwindi on a grey vertosol soil with a range of total available soil water at sowing.

Table 6. Effect of using biomass at floral initiation and flowering and different animal performance assumptions on the proportion of years that grazing a crop is more profitable than continuing to grain harvest.

Starting SW (mm)	Standard assumptions: Floral initiation	Standard assumptions: Flowering	Reduced utilization by 15% at flowering: Floral initiation	Reduced utilization by 15% at flowering: Flowering	Reduced FCR by 0.03 kg LW/kg consumed: Floral initiation	Reduced FCR by 0.03 kg LW/kg consumed: Flowering
0	0.63	0.80	0.63	0.75	0.63	0.75
50	0.43	0.65	0.43	0.49	0.43	0.49
100	0.24	0.55	0.24	0.25	0.24	0.25
150	0.12	0.53	0.12	0.10	0.12	0.10
200	0.02	0.43	0.02	0.02	0.02	0.02
full	0.00	0.22	0.00	0	0.00	0.00

Conclusions

Generally this analysis has conservatively estimated the grazing value that might be obtained from a winter growing cereal crop in northern NSW and southern Qld. Yet it suggests that there is significant capacity to make use of them as a forage source. This is particularly the case, when crops are sown on marginal levels of soil water and in dry low yielding years. In these situations feed supply is often limited and utilising a failing crop may have even greater value for maintaining stock. It remains to be determined if sowing a crop on marginal levels of soil water with the anticipation of using it for forage, compared to maintaining a fallow to await better sowing conditions, is economically rational decision. A further analysis for sorghum in the region will be conducted and similar results are expected.

APPENDIX 4.

Draft report - Using sorghum as a dual purpose crop by grazing ratooned stubble.

<u>APPENDIX 4</u>. Draft report - Using sorghum as a dual purpose crop by grazing ratooned stubble

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Summary

The decision to ratoon grain sorghum after harvest has implications for following crops. Water is the underlying driver of northern farming systems and the decision to use water for the production of additional biomass may have implications on yields of the next crop.
Will the water used by a ratooned unsprayed sorghum crop significantly reduce the starting water of a following crop, resulting in reduced yield? A simulation analysis using the APSIM-grain sorghum module and a modified forage sorghum-module were used to assess the implications of ratooned sorghum biomass on the plant available water for following sorghum crops.
Allowing October sown sorghum crops to ratoon after harvest reduced the stating water for a following October crop by an average of 14 mm at Warialda and 23 mm in Nindigully. This result shows if water is the sole decision criteria, then in the majority of seasons allowing sorghum to ratoon would significantly impact on the PAW of following sorghum crops.

Introduction
Divided opinions exist as to the suitability of using sorghum as a dual-purpose crop and grazing ratooned regrowth after grain harvest. It is argued that allowing sorghum to re-grow depletes stored soil water reserves potentially limiting the yield of following crops. The counter argument suggests the lost yield to be insignificant compared to the benefit of supplementing the feedbase. Quantifying the impact of regrowth on stored PAW will inform and assist in understanding the tradeoffs associated with grazing sorghum stubble.

Methods

The APSIM simulation model was used to identify how much water was depleted from the soil by ratooning sorghum. However the current grain Sorghum module in APSIM does not allow grain sorghum to ratoon. A simplified grain sorghum module based on forage sorghum was developed and parameterised to produce similar biomass and water use results to grain sorghum. This model was used in combination with the grain sorghum module to assess the impact of allowing crops to ratoon.
All simulations were performed on a Grey Vertosol soil with a PAWC sorghum of 220 mm. Simulations were run using the Warialda (located in the east of the northern cropping region) and Nindigully (located in the west of the cropping region) daily meteorological records for the years 1957 to 2006. Sorghum was sown at a crop density of 70,000 plants per ha on a 1m row spacing. Both grain and forage sorghum were fertilised equally by the addition of 150 kg/ha of urea at sowing, no additional nitrogen was applied to the ratooning crop.

Results

The forage sorghum module was adjusted to reproduce similar biomass and water use values to the grain sorghum module (figs 1,2,3). However, at this stage the water use by the forage sorghum module is higher than that of the grain sorghum (fig 2).

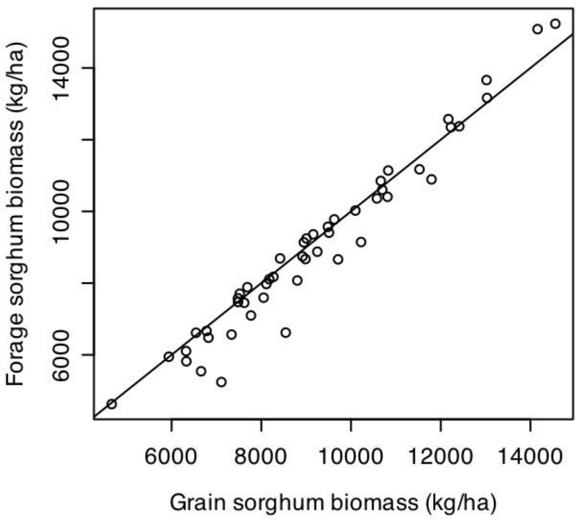

Figure 1. Modelled biomass predictions of the existing APSIM-Sorghum module *v* the modified APSIM-Forage sorghum module

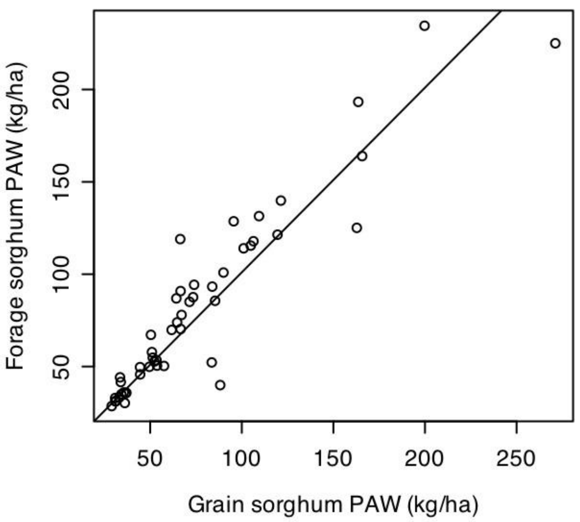

Figure 2. Modelled plant available water (PAW) predictions of the existing APSIM-Sorghum module *v* the modified APSIM-Forage sorghum module

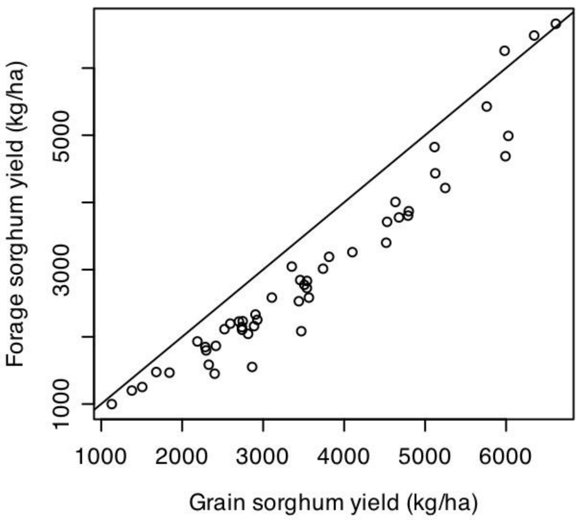

Figure 3. Modelled grain yield predictions of the existing APSIM-Sorghum module *v* the modified APSIM-Forage sorghum module.

Grain yield was not reproduced as well with the new model consistently under predicting compared to the grain sorghum module (fig. 3). The new model successfully ratooned after harvest and continued to produce biomass into the cooler months; all ratooned sorghum was killed on the 1 of May. No validation of the ratooned biomass is available so biomass estimations are only indicative.

Allowing a sorghum crop to ratoon and use water between grain harvest and the 1st of May produced a significant difference ($P < 0.05$) in PAW compared to a non ratooned control when sampled at winter crop sowing (15 May) at Nindigully and Warialda, but was only significant at Nindigully when sampled in October. The magnitude of this difference is presented in the difference plots (figs 4,5) where the paw of the forage crops where subtracted from the grain crops.

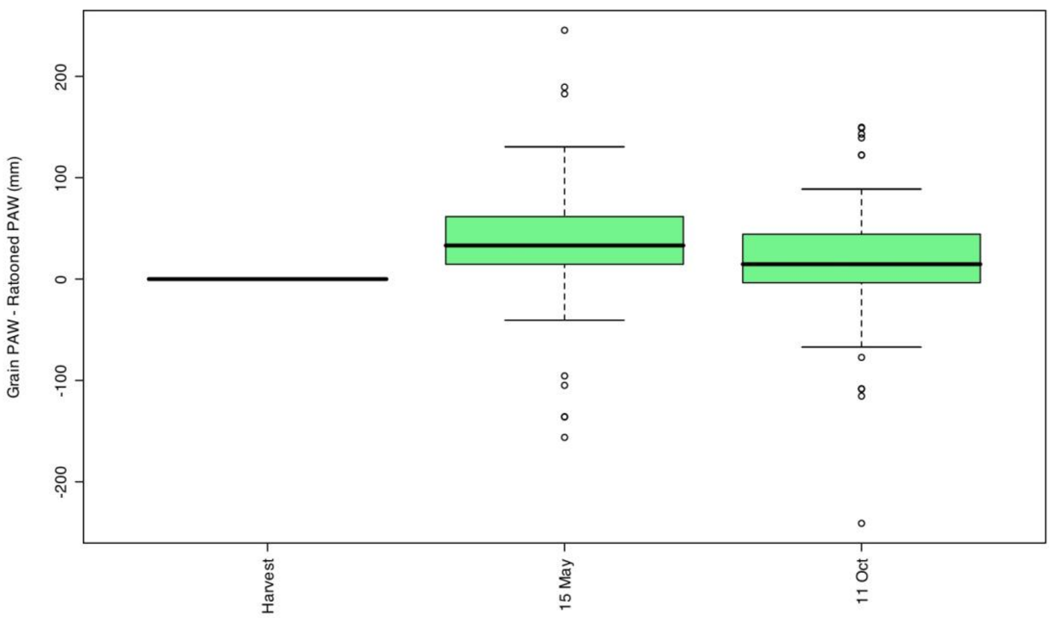

Figure 4. Box and whisker plots showing the difference in plant available water between grain sorghum and ratooned sorghum at sorghum harvest (15-20 Jan) winter crop sowing 15 May and summer crop sowing 11 October for crops sown at Warialda.

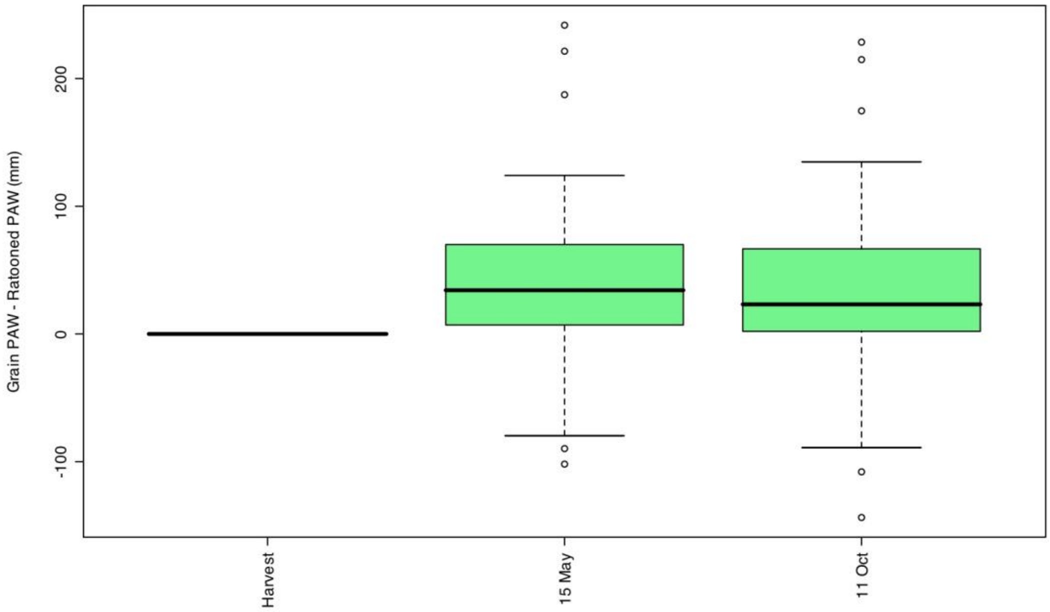

Figure 5. Box and whisker plots showing the difference in plant available water between grain sorghum and ratooned sorghum at sorghum harvest (15-20 Jan) winter crop sowing 15 May and summer crop sowing 11 October for crops sown at Nindigully.

No difference in soil PAW was observed between the ratooned and non ratooned sorghum crops by the October sowing date for crops grown in
Warialda, but a significant difference existed in Nindigully. On Average the difference at winter crop sowing (15 May) between grain sorghum and sorghum allowed to regrow was 33 mm and 34 mm for Warialda and Nindigully respectively, and 14 mm and 24 mm in October for Warialda and Nindigully respectively

The Impact on the yield of a following grain sorghum crop sown in October was not significant despite back to back grain sorghum crops consistently out yielding grain sorghum following a ratoon at both sites (Fig 6 ,7). The ratoon crop had a grater impact on grain sorghum yields at Nindigully due to the lower potential rainfall ~520 mm compared to 650 mm.

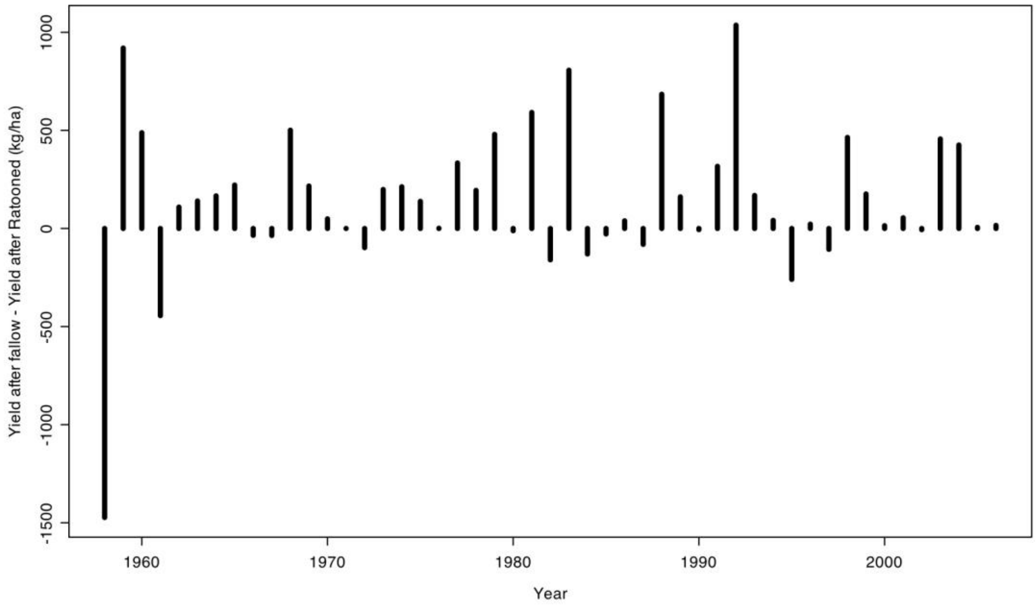

Figure 6. Difference in yield between grain sorghum grown at Warialda after a short fallow and grain sorghum after a ratooned sorghum crop (grain-ratoon) sorghum was sown on the 15 October.

On average the production of forage by ratooning sorghum after grain harvest cost the following sorghum crop 108 kg/ha of grain at Warialda and 332kg/ha of grain in Nindigully. An estimate of the additional biomass produced by ratooning the crop an average ~ 7121 kg/ha at Warialda and ~6469 kg/ha at Nindigully

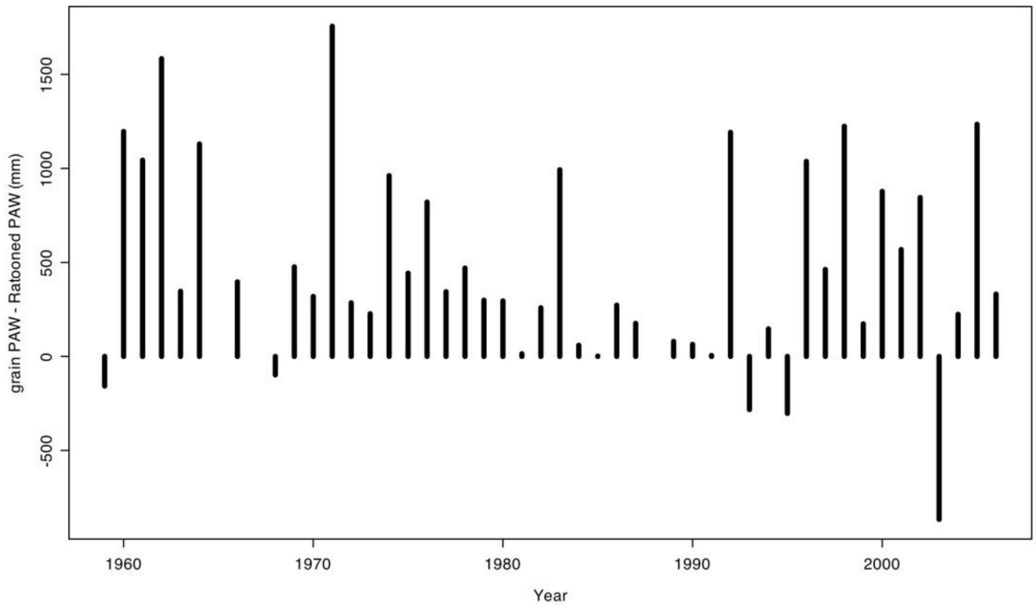

Figure 7. Difference in yield between grain sorghum grown at Nindigully after a short fallow and grain sorghum after a ratooned sorghum crop (grain-ratoon) sorghum was sown on the 15 October.

Conclusion

The view that allowing a sorghum crop to ratoon will significantly impact on the starting PAW of following crops is generally supported by these results especially in the low rainfall area of Nindigully. In Warialda sufficient rainfall fell over the summer to replace the majority of the water used by the ratoon by October, However despite this yield of the following crops was affected, as seen in figure 6, but this difference is not significant.
If the intention is to double crop winter crops after sorghum then the ratooned sorghum's PAW will be significantly lower.

If the decision to ratoon sorghum is singular and only involves the trade-off between water for biomass or water for the following crop. Then the decision to ratoon will impact on the next crop but not significantly. However, as with many farming decisions trade-offs are pluralistic and other considerations will impact on the decision.

Basing a decision simply on available water is valuable, but simplistic. What this analysis does not consider is the management implications of ratooning sorghum. Such implications are mixed and varied, but include: the creation of a green bridge for disease and insects, poor weed control, reduced soil cover and the tie up of nitrogen reserves and implications on deep drainage and erosion. Future work will look at some of these components and tie these with surveyed responses from farmers examining the motivation of farm practitioners to ratoon sorghum stubble.