A review of the feed base to support a WA cattle backgrounding industry

Predicting cattle performance and identifying knowledge gaps

A report prepared for the West Midlands Group

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Executive Summary

The Western Australian cattle backgrounding sector is currently small, but there is potential and a need to grow. Backgrounding plays a critical role in linking production systems that specialise in cow-calf production and the finishing and processing sectors. A backgrounding sector can play a vital role in smoothing the supply of cattle along the supply chain, effectively dampening the fluctuations in weaner turn-off, and producing cattle at the required body weight for finishing or processing.

Given the position of the backgrounding sector in the value chain, it has a potential risk of being subjected to market constraints from either end of the supply chain, which means it must be an efficient and able to cope with changes in prices, supply or demand. The only way this can be achieved is with a robust and reliable feed base that can be efficiently converted to weight gain.

In this review, the potential for current and future forage systems to meet the demands for cattle growth were assessed using a 'case study' of a backgrounding system that aimed to produce at least 0.61 kg/head/day throughout the year. The systems were modelled in the northern, central, southern and eastern agricultural regions. The modelled case studies showed that average productivity over a production cycle of 11 months (Oct-Sep) ranged from about 160-200 kg/ha/year.

The main conclusions and recommendations are:

1. The feed base for cattle backgrounding must be able to tolerate variable seasonal conditions and a changing climate.

2. A diversity of forage species will be required to meet nutrient requirements over time and space.

3. A feed base that relies on annual pasture species is inadequate. The required amount of supplementary feeding nearly eliminates a profit margin.

4. Grazing large paddocks of crop stubble at low stocking rates can theoretically contribute to cattle feed requirements over summer, supplementary feeding with both energy and protein will almost certainly be required in practice.

5. Perennial forages complement annual pastures by providing green feed in summer and autumn. However, there remain hurdles to widespread adoption related to costs or risks of establishment, persistence and nutritive value. There are real, practical options available, but a combination of perennial forages will be required, including grasses and shrubs.

6. There is a need to co-ordinate knowledge and experiences, and to establish and maintain field experiments and demonstrations. Forage productivity in the medium- to longer-term requires G x E trials in different regions and soil types. A sub-set of species that are locally relevant should be maintained at a scale suitable for grazing studies to build confidence in the productivity of cattle backgrounding.

7. Trials on responses to fertiliser application (e.g. tagasaste and phosphorus), and trials that test livestock responses to nutrient supplementation, are required so producers can determine whether the costs of providing extra nutrients via fertiliser or feed supplements are outweighed by benefits in livestock productivity.

8. The area required for perennial forages to meet the feed demands of 'extra capacity' identified in an industry report is considerable if the backgrounding sector is to genuinely reduce the seasonality of cattle off-take to the finishing and processing sectors. An average of 15,000 ha of perennials will be required in each of the main agricultural regions (northern, central, southern and eastern) to meet the proposed 'extra capacity' for backgrounding.

9. There are two broad approaches to achieve the required areas of perennials: either (a) a large number (>100 farms) in each agricultural region, each with about 100 ha of perennials on areas not suitable for cropping, or (b) whole-farm conversions to backgrounding operations are required. Neither is likely to occur without a coordinated effort of research, demonstration, on-going support and open communication.

10. An adequately resourced network of producers, researchers, processors and other industry support personnel that is focussed on cattle backgrounding would help build required momentum, influence research and share knowledge.

Contents

1. BACKGROUND

1.1 New opportunities

There is growing interest in expanding the cattle backgrounding sector in Western Australia, with young pastoral cattle being brought to the agricultural regions of Western Australia to gain extra weight, within a specified age, to enter targeted supply chains.

A north-south supply chain has operated at varying levels of participation for decades, but the circumstances now make this a unique time. A key difference from the past is the alignment of these three factors:

1. High beef prices that are forecast to remain favourable for the medium term, driven by high demands from south-east Asia;

2. Growing awareness and interest in dedicated supply chain partnerships, and other models of alliances to increase predictability in cattle supply and quality;

3. A desire and need for more coordination along the value chain to help manage price and supply risks between the sectors of production, processing and marketing.

With these three factors, there is a greater need for a cattle backgrounding sector in WA to receive cattle from pastoral cow-calf operators and prepare them for finishing or direct sale into the market. The backgrounding sector is a lynchpin in the supply chain, sitting between calf production and the beef market.

Consequently, there needs to be a high level of certainty in the number of cattle that can be backgrounded, despite variable seasonal conditions, and in the rate of liveweight gain of cattle so market specifications can reliably be met.

Because of the position of the backgrounding sector in the value chain, it is at risk of feeling cost pressure from either end of the supply chain. A backgrounding operation therefore needs to be efficient, and based on a firm understanding of the costs of production. As a sector, it needs to be profitable, reliable and flexible. This is possible, but with a heavy reliance on an efficient and resilient feed base, and a high level of management skill.

1.2 The feed base

The crux of a profitable backgrounding operation is the feed base. It determines animal productivity, cost of production, and certainty across seasonal conditions.

For farmers to consider cattle backgrounding, they will need to have a high level of confidence in:

1. What pasture and forage species to grow;

2. The productivity of the forage over time – between seasons and between years;

3. Whether supplementation is required and what cost of supplementation is affordable;

4. How cattle backgrounding fits within their existing whole-farm system, which in most cases involves cropping;

5. The risk profile (which depends on points 1-4 above), what level of investment is worthwhile and how to transition into cattle backgrounding in a staged process.

This review aims to provide information on these points. I have calculated animal requirements to evaluate how well the current, annual feed base can meet animal demand, and how well a feed base that includes perennial forages can overcome shortfalls in the supply of metabolisable energy (ME). Where there is a shortfall between animal requirements and feed supply, I have calculated the level of supplementation required to meet production targets.

1.3 The case study scenario

To make the calculations of cattle performance, I have used a scenario of young cattle weighing 250 kg arriving from pastoral stations to a backgrounding farm in October. The target is for the animals to gain 200 kg of weight within 11 months, i.e., before the next season's animals arrive, and before a falling market at the end of spring, when larger numbers of animals (mostly from southern production systems) are turned-off (Ryan et al., 2009). A backgrounded animal weighing 450 kg would be suitable to enter a 100-day feedlot system.

Based on these parameters, the required average daily gain (ADG) for the 11-month grazing period is 0.61 kg/head/day. A higher ADG would be beneficial for faster turn-off and also to increase the probability of attaining higher prices earlier in the year. An ADG of 0.61 kg/head/day can be therefore be considered as a minimum target, although if a higher ADG is reached in some months, a lower ADG in other months may still be acceptable.

Clearly, changing animal weights (starting or finishing weights) or the time of year that the cattle are backgrounded will change the relationships between feed supply and demand. However, by using this scenario as a case study, it is possible to quantify production costs and times during the year when risk is greatest, and to identify gaps in knowledge.

1.4 The WA scene

In reviewing the current and potential capacity for a WA cattle backgrounding industry, I've considered the point of view of new entrants into the sector. What do they need to know, and is that information available and in a form that can be readily applied on-farm?

The agricultural regions in WA have tended to move from a true mixed farming system (crop and livestock) to crop-dominant systems. With economic pressures in the cropping enterprise such as rising input costs and variable grain prices, some farmers are identifying areas of their farm that have become economically marginal for cropping. These areas may be suitable for forage (or fodder) production.

Paddocks have been getting larger as cropping machinery has got bigger and livestock numbers declined. On one hand, the removal of small paddocks represents an opportunity for designing new livestock systems, such as wagon-wheel paddocks around a central hub, suitable for cattle. On the other hand, the decline in livestock infrastructure, especially water supply, means it is a bigger and more expensive job for producers to move back into livestock.

Another interaction between cropping and livestock is the use of crop stubbles for feeding animals over summer and autumn. As crop areas have got larger, there is potentially more stubble available to fill a summer-autumn feed gap. But the feeding value of stubbles in modern cropping systems is lower than stubbles a few

decades ago. This review will consider the use of crop stubbles in section 6.

A question for each producer to consider is whether the areas identified on their farm as marginal for cropping are sufficient to sustain a profitable and viable backgrounding enterprise. This is a critical question because land capability has a large effect on the opportunity costs. If a producer needs to reduce their cropping program to allocate land for pasture to feed cattle, the economics are quite different from a producer who has a larger area of land that is not being cropped.

DAFWA's report on "Production potential within the Western Australian beef industry" concluded that there was capacity for nearly 70,000 more steers in the agricultural region in a median year. Why, then, isn't there already a growing backgrounding sector to make use of this capacity? I suggest there are two main reasons:

The first is uncertainty in feed production due to seasonal variability. With fluctuations in rainfall patterns, it is difficult for producers to 'lock in' a turn-off specification (weight and age) to meet supply chain expectations unless the feed base becomes more resilient to a variable climate. Without a resilient feed base, backgrounding producers must, in poor seasons, rely on either using more supplementary feed or reducing the number of animals that they receive. The first option can be expensive and the second is not conducive to building long-term supply chain partnerships unless there is a 'collective' approach across regions to ensure a near-consistent turn-off of backgrounded cattle each year.

The second reason is that the existing feed base is not sufficient for cattle to gain weight at the required rate from late summer to early winter. As stated in the DAFWA report, pasture quality is expected to limit cattle growth for 4-5 months in a typical (median) year. This gap will be even larger in low decile years. Including more summer-active, but drought-tolerant perennial forages into the feedbase is essential to address this key issue.

A resilient feed base is one that is more diversified, but this comes with management complexity that may deter some producers from entering the sector.

The areas required and the numbers of producers who will need to establish perennial forage systems are significant. The scale of change will not happen on it's own. Good support systems will be required to encourage and maintain new entrants.

2. THE HEADLINE 'NEED-TO-KNOWS'

For farmers to set-up and operate a successful cattle backgrounding enterprise, they will need to know:

1. Animal requirements to meet market specifications
2. What forage species can be grown
3. Forage productivity and nutritive value over time
4. The area (hectares) required for a given number of animals.

2.1 Animal requirements to meet market specifications

To answer the question of how much feed, expressed in MJ of metabolisable energy (ME), is needed to meet target cattle growth rates, I have used the data and predictive equations from "The Nutrient Requirements of Domesticated Ruminants" (CSIRO, 2007). Given the large body of research that underpins the equations in this publication, there can be a high level of confidence in the general conclusions.

Actual growth rates in any given situation will depend on breed and local conditions such as ambient temperature, terrain and distances that animals must walk and, although the equations used to calculate energy requirements include factors to adjust for these variables, they do not have a major affect on ME requirements compared to live weight and growth rate.

Nevertheless, local data on cattle growth, feed intake and feed conversion should be obtained to validate the predictions in this report, and to compare data across different production systems in WA. This will build confidence in identifying the costs of production and the capacity to meet market specifications

2.2 What forage species can be grown?

There are broad recommendations in the public domain on the suitability of pasture or forage species to different soil types. However, much of the information needs to be converted into practical guidelines and advice for producers who may be relatively new to integrated livestock systems. Without a coordinated approach to collate and disseminate and share information, farmer who is interested in exploring his/her potential for cattle backgrounding would need to invest considerable time or seek the specialist advice from peers, consultants, universities or DAFWA.

There is a need and opportunity to co-ordinate the knowledge and experiences available in WA, to link field demonstrations – which can 'come and go' without always leaving a legacy of information for the future – with research and development – that is often not supported for long enough for new knowledge to be converted to farm practices.

Specific information is required on combinations of forage species to best meet animal requirements, manage seasonal risk and sustain production over time. A combination of forage types will be essential to meet the requirements of animals over time, but R&D tends to focus on one cultivar or species at a time. Long-term field-based trials and experiments to deal with the complexity of different forages (used together or at different times) are required.

2.3 Forage productivity and nutritive value over time

In this report, I used first principles based on ME requirements of animals, and research data on forage production to generate data on cattle performance. The case study modelling in this report does not, because of a lack of available information, take into account changes on nutritive value of different forages over time and space, or long-term biomass productivity.

Adding a perennial forage to the feed base will be essential to reach the target growth rates of cattle, at least if large amounts of supplementation are to be avoided (see Section 4). For perennial grasses to fill a feed gap in summer and autumn, they need summer rain. How much reliance can be placed on perennial grasses to achieve adequate pasture biomass and quality is not certain under the variable climate of south western WA, perhaps with the exception of the south coast that has a more reliable summer rainfall pattern. Summer rainfall as a proportion of annual rainfall is expected to increase, which will suit summer-active perennials, but rainfall variability is also expected to increase, which reduces our capacity to predict forage availability and quality.

2.4 The area (hectares) required for a given number of animals

Estimating the area of different forages that are be required is relatively straightforward because it is a mathematical calculation relating animal nutrient requirements to feed supply. Clearly, though, the quality of information on feed productivity (month-by-month and year-to-year), feed quality (nutritive value) and animal nutrient requirements used in the calculations will ultimately determine the accuracy of the calculations.

Calculating the required area for a given farm can be done to guide decisions about the number of cattle that can be backgrounded at different times of the year. But we also need to calculate the total area required in a region if industry development goals are to be achieved. Are the areas realistic and in what time frame?

A critical mass of producers across the agricultural region is required to provide a backgrounding sector that can tolerate different climatic scenarios and, collectively, ensure continuity in supply.

3. PREDICTING GROWTH RATES OF BACKGROUNDED CATTLE

3.1 Predicting animal requirements

All prediction equations were obtained or derived from 'Nutrient Requirements of Domesticated Livestock (CSIRO 2007). Feed intake was predicted from bodyweight and feed dry matter (DM) digestibility (based on data in Table 6.4 in CSIRO, 2007).

In comparing feed intake calculated in this way with other information on feed intake of growing cattle, my predictions may be slightly lower (c. 10%) than other values. The method others have used is not always explained, but a common, simple approach is to calculate intake as a percentage of body weight (e.g. 3% of body weight). Such an approach can be sufficient for gauging approximate performance levels, but when feed quality is low, which is often the case in WA's summer and autumn, it will over-estimate feed intake.

The intake of lower quality feed is often limited by the rate of passage through the gut (Weston 1986). It remains possible that my predictions of intake are lower than actual, because modern genotypes of cattle selected for growth will probably also have had inadvertent selection pressure for a higher voluntary feed intake, except where there has been a deliberate selection pressure for more efficient conversion of feed into weight gain.

Animal maintenance requirements were determined from prediction equations based on body weight, age and the ME content of the diet. Where data for forage ME content was available, that was used, but where data on pasture quality was presented as DM digestibility (DMD or OMD), these values were converted to ME based on equations in CSIRO (2007).

The calculations are based on a *Bos indicus* x *B. Taurus* cross, although (as stated above) the difference in maintenance requirements due to a breed factor are not particularly large compared to other factors such as body weight.

The ME available for weight gain was calculated as the difference between ME intake and ME required for maintenance, assuming 60 MJ ME is required for 1 kg of weight gain. The rate of liveweight gain (ADG) was calculated on a monthly basis.

I make the strong recommendation for trials to measure and validate feed intake and growth rates of pastoral cattle backgrounded under WA conditions. Different breeds and places-of-origin should be tested, under a range of forage types. It is conceivable, based on data comparing the Damara and Merino sheep breeds, that breed differences in intake and growth rates are most evident when feed quality is low (Wilkes et al., 2012). That is, genotypic and epigenetic factors may be particularly important during the periods of lower feed quality in summer and autumn.

3.2 Predicting pasture productivity

Annual pasture growth rates (PGR) were obtained from online data from Pastures from Space (http://www.pasturesfromspace.csiro.au). Baseline PGR values were obtained by averaging across 3-4 locations within the following four regions:

- Northern agricultural
- Central
- Southern (Esperance region), and
- Eastern wheatbelt.

PGR data over a sequence of 5 years from recent historical data were used in this report to remove effects of particularly dry or wet seasons. However, this of course means that the data represent an average level production, and does not capture the risks associated with large variation in pasture productivity from year to year.

Using the average PGR within each of the four regions, accumulated biomass in October was used as the starting point for feed on offer. I calculated the area of pasture required so that feed on offer did not limit voluntary feed intake. I assumed pasture utilisation of 40%, which is probably higher than most commercial situations, but represents a suitable target rate of utilisation. Feed on Offer (FOO) in each Annual pasture in summer/autumn pasture often has an ME content of only 6-8 MJ/kg DM (digestibility of about 45-55%), and sub-tropical (summer active) perennial grasses in winter can be only 7.5-8.5 MJ ME/kg DM (50-60% DM digestibility). Clearly there is a complementarity between the annual pasture and perennial grasses in month was calculated as the sum of uneaten pasture from the previous month – i.e. pasture carried forward – plus any additional pasture that grew in the current month.

3.3 The importance of feed quality

To highlight the importance of pasture quality, Table 1 shows the predicted feed intake for animals weighing 250 or 350 kg fed a diet containing either 9 MJ ME/kg DM (62% DM digestibility) or 11 MJ ME/kg DM (74% digestibility).

With a diet of 9 MJ ME/kg DM, intake is limited by feed quality, and growth rate will be below the target. Feed intake is 2.5-2.9 kg/day less than it needs to be for cattle to meet the target growth rate of 0.61 kg/head/day.

At 11 MJ ME/kg DM, the target growth rate of 0.61 kg/head/day is achieved. The calculated weight gain exceeded 0.7 g/head/day.

A diet of about 10.5 MJ ME/kg DM (71% DM digestibility) is required to avoid voluntary feed intake restricting growth rate below the target of 0.61 kg/head/day.

terms of when they are each at maximum quality. If annuals provide the bulk of the diet in late winter and spring, and perennials in summer and autumn (at least when summer rainfall is sufficient), an ME content of at least 9-11 MJ ME/kg DM can be expected, which should avoid problems associated low voluntary feed intake.

Table 1. Predicted feed intake and weight gain for a 250 or 350 kg animal fed a diet of 9 or 11 MJ ME/kg DM, and the required intake to reach a growth of 0.61 kg/day (which is the average growth rate required in the scenario of backgrounding animals to enter a 100-day feedlot program at 450 kg).

Body weight (kg)	250		350	
Feed quality (MJ ME/kg DM)	9	11	9	11
Predicted feed intake (kg DM/head/day)	5.3	6.9	5.9	7.5
Predicted growth rate (kg/head/day)	0.25	0.75	0.18	0.71
Required intake to grow at 0.61 kg/head/day	7.8	6.2	8.8	7.0

4. CATTLE GROWTH RATES WITH ANNUAL PASTURE SYSTEMS

4.1 Cattle productivity with annual pasture systems

With annual pastures alone, the net weight gain over 11 months was 64-80 kg/head, depending on the region, which represents only about one-third of the target weight gain.

Weight loss occurred over summer and autumn on all regions due to low feed quality of senesced annual pastures. Consequently, cattle did not return to their October live weight until about June.

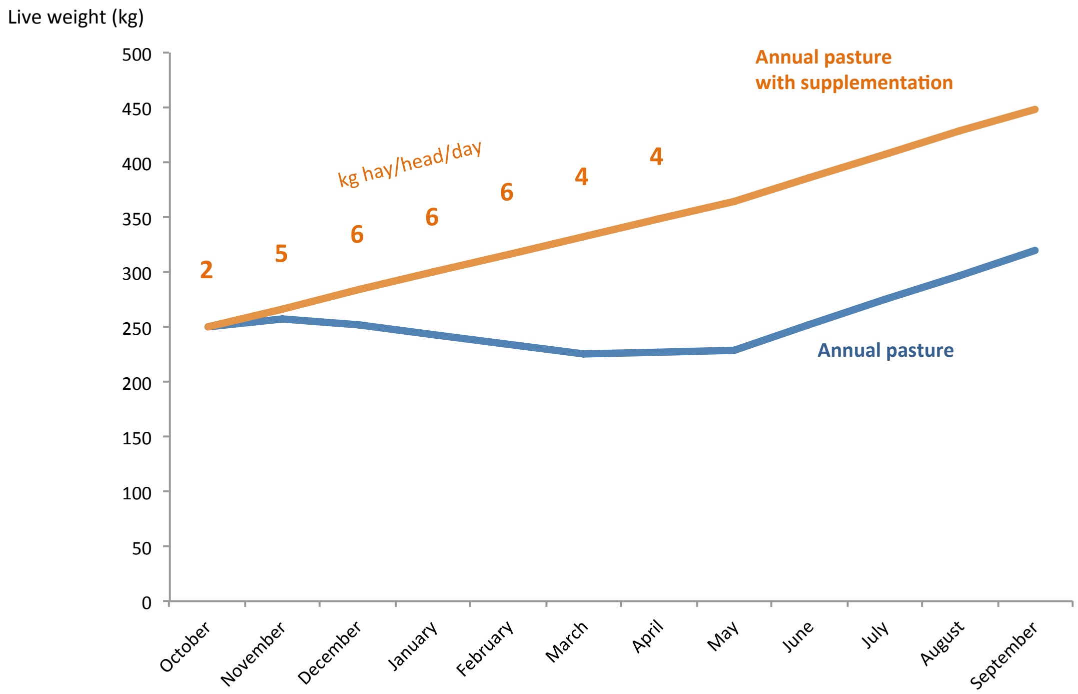
Growth rates between June and September were about 0.75 kg/head/day.

4.2 Supplementation requirements with annual pasture

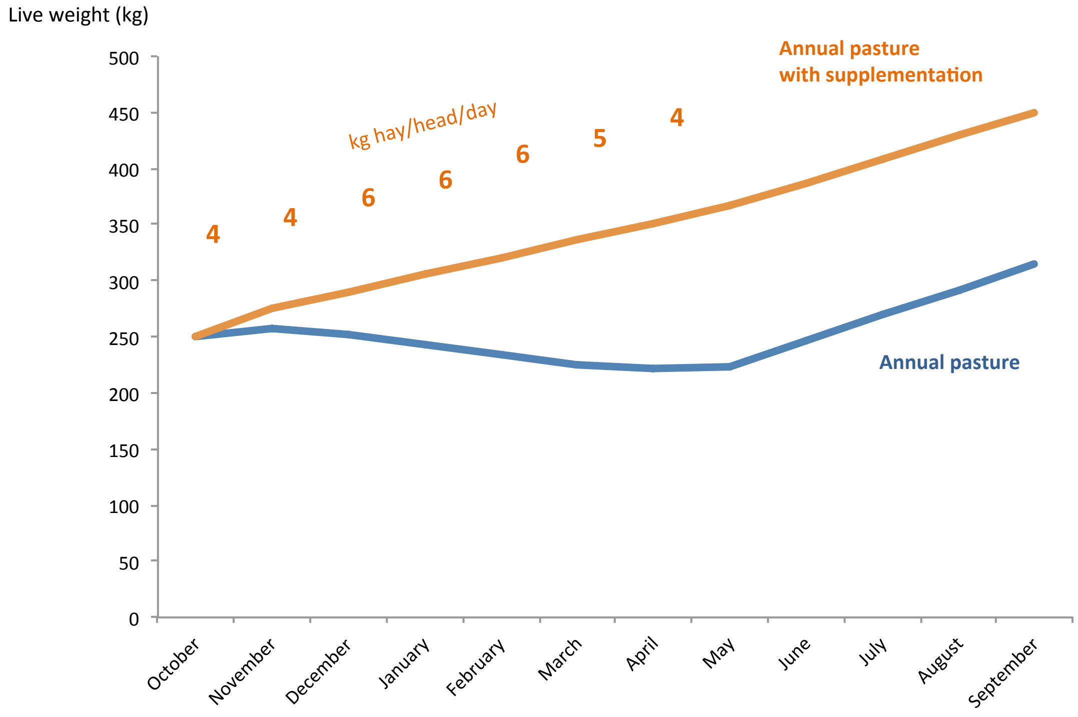
The level of supplementation required to reach the target live weight of 450 kg in 11 months was calculated using hay with an ME content of 9 MJ ME/kg DM (e.g., a moderate quality oaten hay).

The predicted growth curves are shown in Figure 2A-D. The required amount of hay supplementation totalled about 1 tonne/head, fed out over 6-7 months.

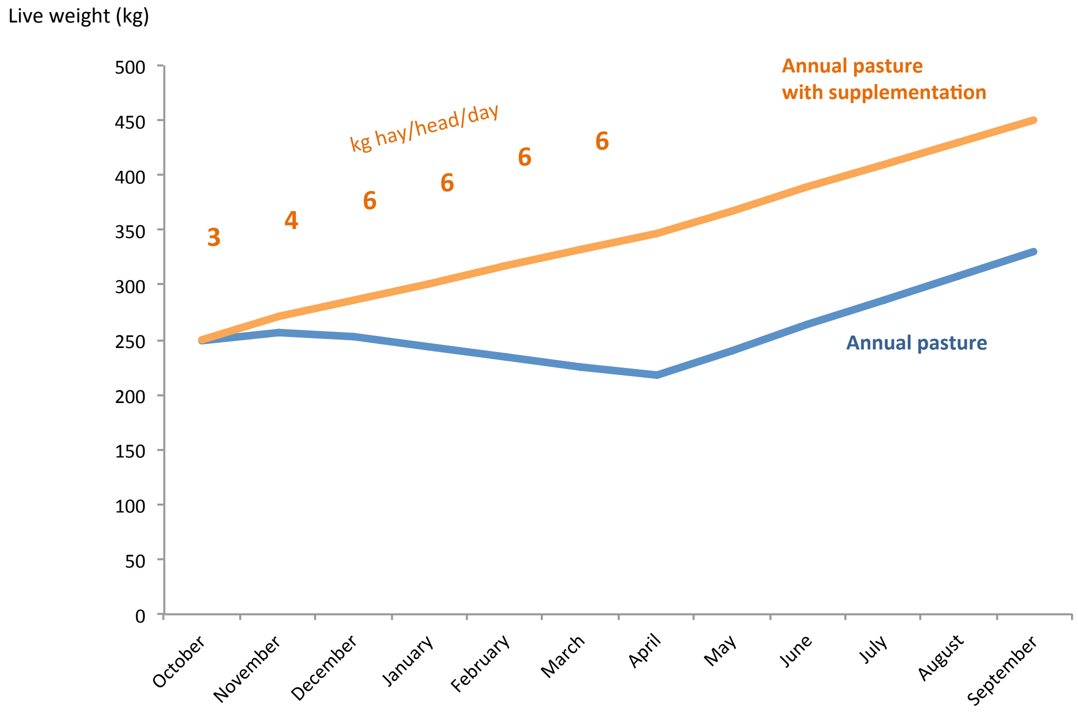
A. Northern



B. Central



C. Southern



D. Eastern

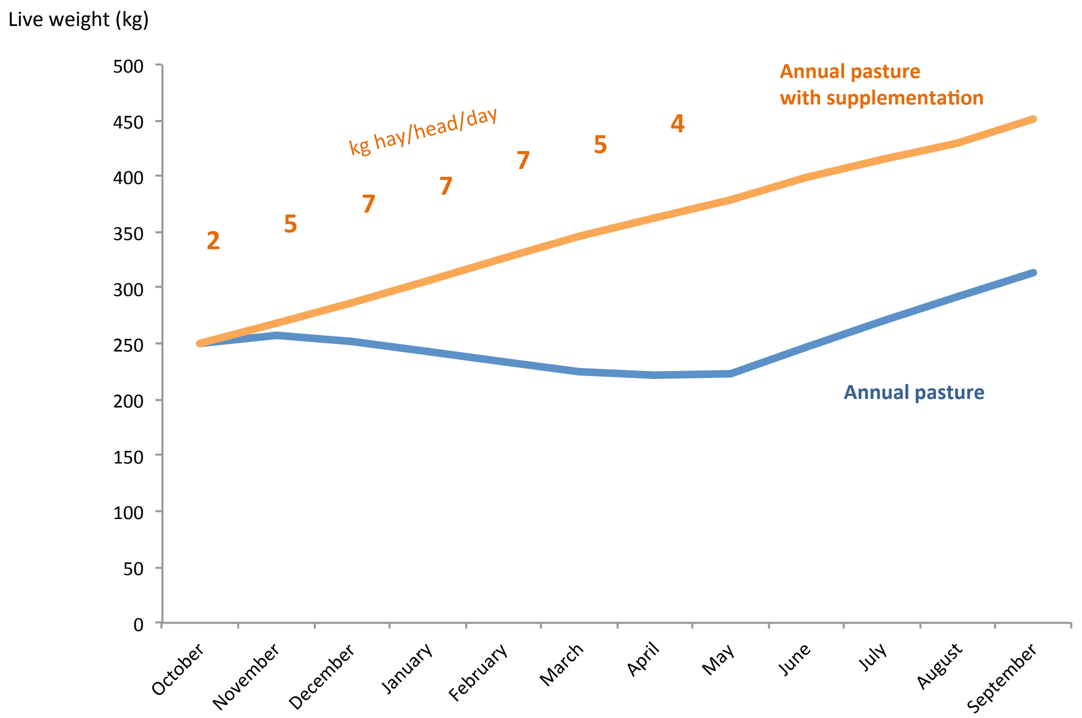


Figure 2. Predicted cattle growth rates on an annual pasture alone (blue line) and with hay supplementation (orange line). The orange numbers above the orange line indicate the daily amount of hay that would be need (kg/head/day) for cattle to reach the target rate of gain.

A. Northern agricultural region. Total hay supplemented was 990 kg/head.
B. Central. Total hay supplementation = 1,080 kg/head.
C. South coast. Total hay supplementation = 930 kg/head.
D. Eastern. Total hay supplementation = 1,240 kg/head.

4.3 What annual pastures can be grown?

There are 13 annual legume cultivars registered in Australia that are 'widely used' or 'moderately popular' (Nichols et al., 2012). There are three subterranean clovers, two Persian clovers, Balansa clover, three medics (strand medic, spineless burr medic, and barrel medic), two serradellas (yellow and French), and biserrula. Other cultivars that have a 'special purpose' or an increasing role in WA include gland clover, rose clover, and arrowleaf clover. Other cultivars are commercially available but not (yet) widely used, and new cultivars are in the research-to-market pipeline.

The suitability of cultivars to different soil types is well defined (Table 2), so producers are able identify the relevant options available to them. However, producers are likely to find it difficult to identify an optimal pasture system that is assembled from a combination of cultivars or species that is suited to their particular circumstances.

An important distinguishing feature of different annual legumes, besides their suitability to different soil conditions, is their relative capacity to provide nutrients and metabolisable energy earlier or later in the growing season. This is important because if the decline in ME at the end of the growing season, for example from 11 to 9 MJ ME/kg DM, were delayed by just one month, the

annual weight gain of backgrounded cattle would increase by about 12 kg/head. For 100 animals, this equates to 1.2 tonnes of live weight and, at $2.40/kg liveweight gain, the extra weight gain would be worth $2,880.

Annual grasses in WA extensive grazing systems tend to be naturalised combinations of ryegrass, barley grass and silver grass. There are no particular traits of great value in these, other than a capacity to provide feed for livestock after breaking rain, especially with barley grass. For mixed crop-livestock farmers, the annual grasses are predominantly seen as a crop weed risk, especially with the development of herbicide resistance.

Table 2. The main annual legume species in use in WA and their suitability to different soil types. (Source: DAFWA Annual pasture legume options for key soil types).

Soil type:	Well drained deep sands	Gravelly loamy sands	Sands	Sand over clay	Loan and clay loam	Winter waterlogged soil
Soil pH:	Highly acidic	Acidic	Neutral to alkaline	Acidic	Mildly acidic to alkaline	
Sub clover		✓		✓	✓	✓
Persian clover					✓	✓
Balansa clover					✓	✓
Gland clover		✓	✓			
Rose clover		✓				
Arrowleaf clover		✓		✓		
Gland clover				✓	✓	
Barrel medic			✓		✓	
Strand medic			✓			
Burr medic					✓	
Yellow serradella	✓	✓	✓	✓		
French serradella	✓	✓	✓	✓		
Biserulla		✓	✓	✓	✓	

5. PREDICTED CATTLE GROWTH RATES WITH PERENNIAL FORAGE OPTIONS IN THE FEED BASE

5.1 Cattle productivity when perennial pasture combined with annual pasture

Perennial forages can be used to fill annual pasture feed gaps in summer, autumn and early winter. Another option to fill a feed gap in early winter is to include the grazing of (dual purpose) cereal crops. I have included this option in this section, even though it is not a perennial pasture, as it represent san additional forage resource to complement annual pastures to improve cattle growth rates.

The options tested in the following calculations of cattle growth rates:

- Northern: forage shrubs, sub-tropical perennial grasses and crop grazing cereal crop
- Central: forage shrubs, lucerne, and crop grazing
- Southern: forage shrubs, sub-tropical perennial grasses
- Eastern: forage shrubs.

These combinations of forage options were not intended to be an exhaustive list of alternative forages, but rather as examples of the extent to which perennial forages could fill feed gaps.

The ME content of the four forage types (shrubs, perennial grass, lucerne and winter cereal) was obtained from published values (McDowall et al., 2003; Jacobs et al., 2009; Dolling et al., 2011; Ward et al., 2013; Moore et al., 2014). When perennial forages were added into the feed base in the modelled case studies in this report, they were used for 2-4 months from November to May, depending on the region. After May, the annual pasture was sufficient to meet animal demands. When a cereal crop was included for grazing, it was used fro the month of June.

For perennial grasses and lucerne, a rotational-style grazing within the allocated area – e.g. strip grazing or subdivision of the total area – was assumed. For shrubs, which re-grow more slowly than perennial pastures, areas were grazed for a period of one month, with each new month of shrub grazing requiring a new area rather than rotating back over previously grazing areas.

Although grazing management was not a focus of my review, it is a critically-important management tool that can have a significant impact on pasture and animal productivity, pasture utilisation, and long-term performance and risk. I assumed forage utilisation of 40% for lucerne and perennial grass, and 60% for crop grazing and shrubs. Perennial shrubs can sustain heavy grazing – e.g., 80% utilisation – as long as there is sufficient time allowed for regrowth before the next grazing. I used 60% utilisation to reflect the combination of shrubs and inter-row pasture.

An improved, or diversified, feed base – consisting of annual pastures, a combination of perennial forages and crop grazing – allowed for a weight gain (over 11 months) of 141, 174, 127 and 128 kg of weight gain for the northern, central, southern and eastern regions, respectively (Figure 3A-D). This is approximately double the weight gain that can be achieved on annual pastures alone, although on average only three-quarters of the nominated target of 200 kg of weight gain.

The perennial forage options were added sequentially into the calendar of grazing to demonstrate how each addition could improve cattle performance by lifting feed quality. The choice of perennial to allocate as the feed for any given month was somewhat arbitrary. The largest feed gap was filled first with the most likely option suited to the region, and then another perennial was used to fill the next feed gap. The relative combination of the different perennial options and the timing of their use will depend on the local circumstances of each farm, especially soil types, rainfall patterns, degree of compatibility with other farm enterprises (such as cropping) and management skills and interest.

Table 3. The allocation of forage options in each month for each region that was use din the modelled case studies. A = annual pasture; S = perennial shrubs' PG = perennial grass; C = cereal crop. The subscripts indicate the order that the additional forage options (replacing annual pasture) were added (see text for details).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Northern	A	A	S_2	S_2	PG_1	PG_1	PG_1	A	C_3	A	A	A
Central	A	A	L_2	L_2	S_1	S_1	S_1	A	C_3	A	A	A
Southern	A	S_2	S_2	S_2	PG_1	PG_1	PG	A	C_3	A	A	A
Eastern	A	A	S_1	S_1	S_1	S_1	A	A	A	A	A	A

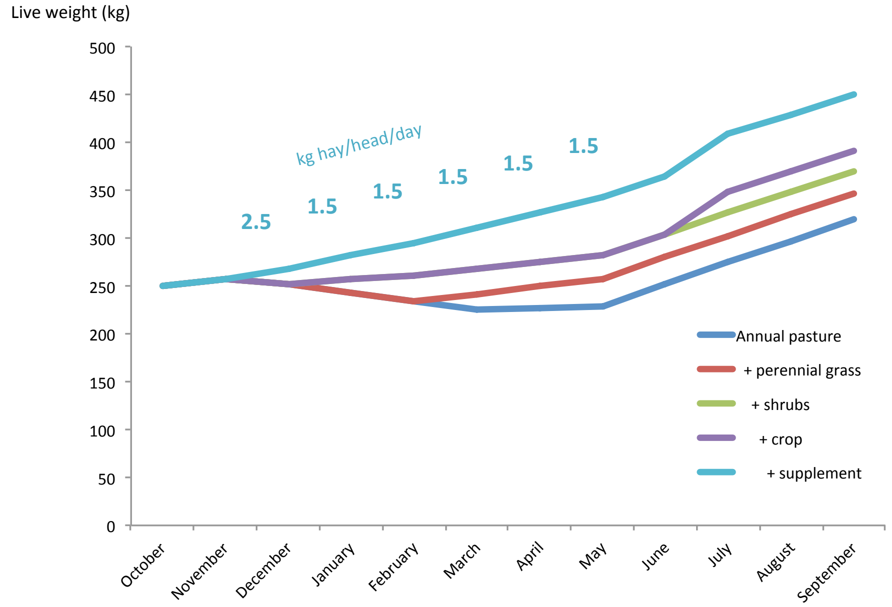
5.2 Supplementation requirements with a feed base consisting of annual and perennial pastures

The amount of supplementary feeding required for cattle to gain 200 kg was calculated using a supplement containing 13 MJ ME/kg DM, such as lupins or a high-energy pellet.

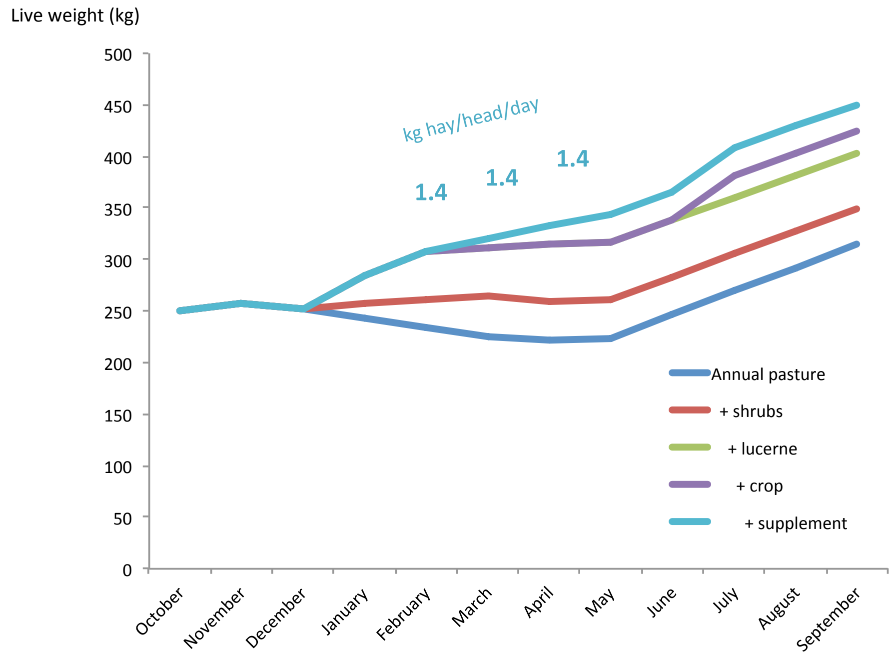
In practice, the cheapest supplement when expressed as price per MJ of ME should be used. For example, if lupins at 13 MJ ME/kg were \$350/t, they would cost \$27/MJ ME, and if hay at 9 MJ ME/kg was \$280/t, it would cost \$31/MJ ME. However, it's worth noting that there may be different animal responses to different supplements that cannot be explained solely by the supplement ME content, and I discuss this later in the report.

The total amount of supplement required to attain the target of 200 kg of weight gain ranged from 126-390 kg/head, depending on the region. Daily rates of supplementation ranged from 1.0 to 2.5 kg/head/day, and the duration of feeding ranged from 3 months in the central agricultural region to 7 months in the south coast and eastern wheatbelt.

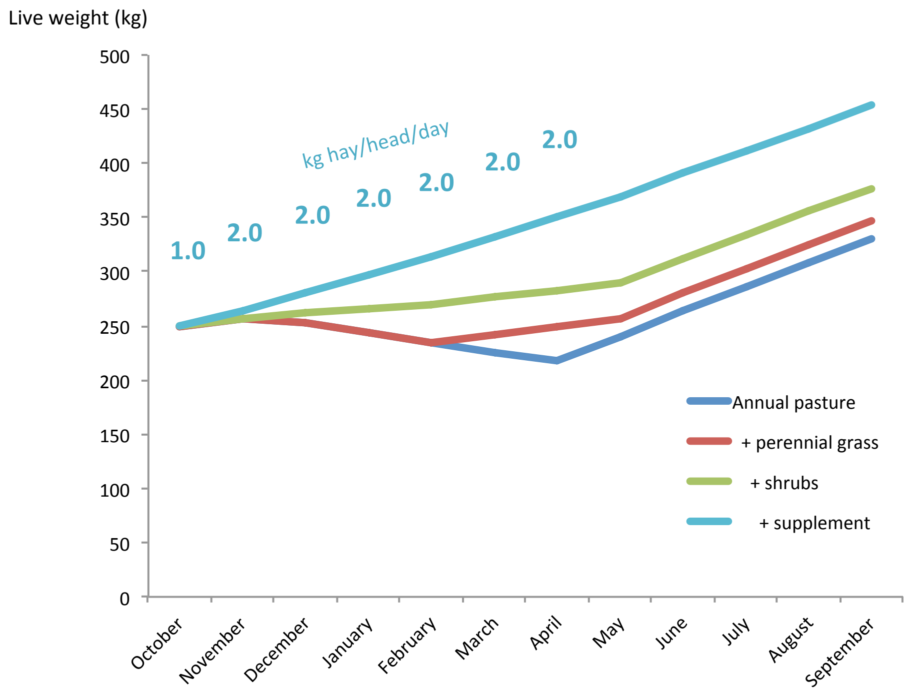
A. Northern



B. Central



C. Southern



D. Eastern

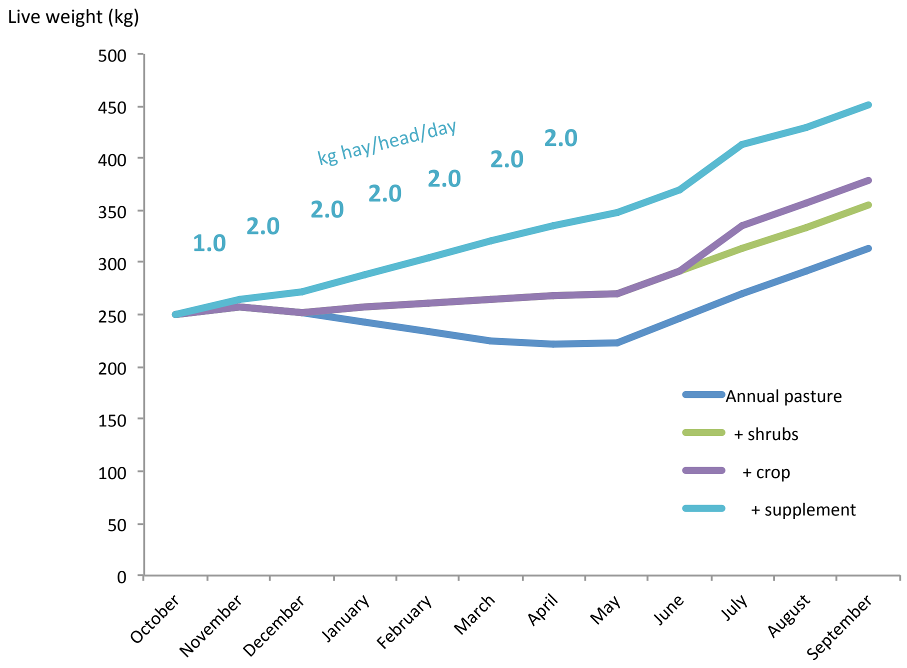


Figure 3. Predicted cattle growth rates on an annual pasture alone (dark blue line) and with the sequential addition of extra forage types. The top line in each graph shows the growth curve with grain supplementation (aqua-coloured line), with the numbers above that line indicating the daily amount of supplement that would be needed (kg/head/day) for cattle to reach the target rate of gain.

A. Northern agricultural region. Total lupin supplementation = 300 kg/head.
B. Central. Total lupin supplementation = 126 kg/head.
C. South coast. Total lupin supplementation = 390 kg/head.
D. Eastern. Total lupin supplementation = 390 kg/head.

5.3 What perennial forage species can be grown?

5.3.1 Perennial grasses

Deep rooted, summer-active perennial pastures offer great promise to increase the provision of nutrients and ME over summer and autumn. There has been a growing body of work on perennial grasses in WA, especially on the acidic sandy soils of the coastal south-west (McDowall et al., 2003; Sanford, 2006;) and on the northern sandplains (Moore, 2006; Moore 2013).

Sanford and Gladman (2004) evaluated a suite of sub-tropical and tropical perennial grasses 13 years ago, but broadscale adoption remains limited to the south coast and in the northern sandplains. The main limitations to increasing the rates of adoption of perennial grasses, identified by Ryan et al. (2009) and Moore (2013) are:

- Establishment risk and cost
- Uncertainty in persistence
- Productivity over summer if summer rainfall events are not adequate
- Fertiliser requirements for perennial grasses

There is not much published data on cattle performance grazing perennial grasses. One exception is Ryan et al. (2009), who compared weaner growth rates on different perennial pastures options: (i) kikuyu and Rhodes grass, (ii) setaria, Bambatsi panic and Gatton panic, or (ii) lucerne. The main factors affecting of herbage biomass were rainfall and, to a lesser extent, soil type (shallower soils yielded lower).

Cattle attained a growth rate of at least 0.6 kg/head/day in two of the three years of the study. The year with a lower ADG had higher rainfall but lower winter temperatures, which reduced perennial grass growth. In this situation, lucerne was a better forage option, with growth rates about 60% higher compared to the perennial grasses.

This result highlights the importance of seasonal conditions on pasture productivity and animal performance, and the need for producers to have a combination of forage types in their farm system to minimise risk.

5.3.2 Perennial shrubs

One of the main attributes of perennial shrubs is a higher level of predictability in biomass and nutritive value over summer and autumn compared to perennial pastures that are more dependent on summer rain. Although shrubs tend to have lower growth rates and biomass (per hectare) than grasses, they are generally a hardier option for a variable climate.

On the deep sands of the northern sandplains, there has been wide uptake of tagasaste, although adoption would appear to have slowed over the past 5-10 years, and some of the existing tagasaste plantations have not been well managed and require rejuvenation (cutting and improving inter-row pastures). On saline land, saltbush-based systems are accepted as providing beneficial out-of-season feed and a practical way to manage and control salinity.

Another system, not yet adopted to the same level as tagasaste and saltbush, is a diverse mix of native shrubs (the 'Enrich system'), which can complement tagasaste and saltbush systems.

5.3.2.1 Tagasaste

The features of tagasaste (Wiley 2006) relevant to a cattle backgrounding system are:

- Drought tolerance
- Well suited to deep sands
- Good feed quality in winter and spring
- Can be grazed continuously by cattle
- High protein content (25% in spring, down to about 15% in autumn)

A limitation of tagasaste is its decline in feed quality in autumn – which coincides with the time of the greatest feed gap with annual-based pastures. Supplementary feeding can overcome this constraint and allow cattle grazing tagasaste to gain weight in autumn.

Lupin supplementation has been identified as a highly effective supplement to tagasaste. For example, in one study (Milton et al., 2000), yearling steers browsing tagasaste were fed a daily supplement of either 2 kg lupin grain, 1 kg lupins + 4.5 kg silage or 9.0 kg silage (Figure 4). Steers browsing tagasaste without a supplement lost an average of 13 kg whereas steers supplemented with lupins gained an average of 38 kg. Milton et al. (2000) concluded "it is possible to achieve a growth rate of around 0.6 kg/day for steers grazing tagasaste at a high stocking rate when supplemented with modest levels of lupins during late summer and autumn."

Phosphorus fertiliser "drives the feed and animal production from tagasaste" (Wiley 2006). As superphosphate application increases from 0 to 400 kg/ha/year over 5 years, liveweight gain increases almost linearly from about 45 to 375 kg LW gain/ha (Edwards et al., 1996). Much of the tagasaste plantations in WA have probably not received much, if any, P fertiliser in recent years. There is almost certainly a penalty to plant and animal productivity, but this has not been quantified.

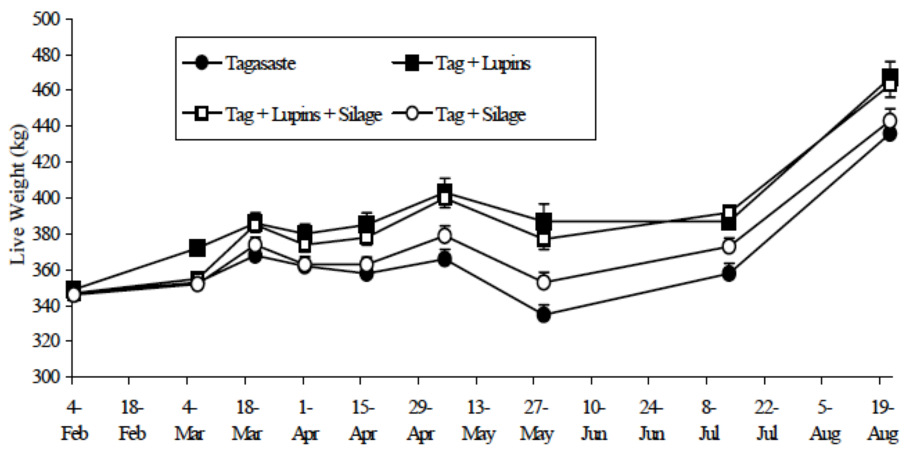


Figure 4. Average live weights of cattle browsing tagasaste with lupins, silage or lupins + silage during autumn, in the northern agricultural region of WA. Supplementation ceased on 29 May (Milton et al., 2000).

5.3.2.2 Native perennial shrubs

Native perennial shrubs can provide green forage in summer and autumn, and complement the nutritive value of annual pastures by providing a source of crude protein and minerals (Revell et al., 2013), although the bioavailability of minerals needs to be confirmed. They are also ideal for grazing in early winter to allow deferment of grazing annual pastures (Monjardino et al., 2010).

Most of the work over the past decade has been with old man saltbush (e.g. Sustainable Grazing of Saline Land (national project) and the Future Farm Industries CRC projects, 'Salty Diets' and 'Enhance'. The added benefits of a diverse species mix of native shrubs have been investigated in the national 'Enrich' project. Three booklets have been prepared that summarise the main findings of Enrich, with the third booklet focussing on practical guidelines for landholders (Revell et al., 2011; 2014; Emms and Revell 2015).

Most of the grazing studies with saltbush or mixed shrub species have been with sheep, but there is no major reason why the results are not applicable to cattle, on a DSE basis.

In fact, when Fancote et al. (2009) compared cattle and sheep on a saltbush-based pasture, they concluded that, when feed on offer is not limiting dry matter intake and fresh water is available, **cattle are able to utilise saltbush as well as, or possibly better than, sheep.** During the first 3 weeks of grazing a saltbush-based pasture, cattle significantly outperformed sheep (15% vs 4% increase in liveweight).

In a recent study at Pingelly (CSIRO and UWA - 'Best choice shrub and inter-row species for reducing methane emissions intensity', Filling the Research Gap program) with a diverse mix of shrub species and annual pasture in inter-row alleys, sheep gained about 200 g/head/day over 6 weeks in autumn without any supplementation (Figure 5).

Liveweight gain was about 2 kg/ha and, if cattle were stocked at the same DSE as the sheep, the equivalent growth rate for cattle would be an impressive 1.6 kg/head/day. Clearly, this needs to be tested and validated, but even if only half this growth rate were achieved (i.e. 0.8 kg/head/day) it would exceed the nominated target of 0.61 kg/head/day for backgrounding cattle (as used in the modeled case studies).

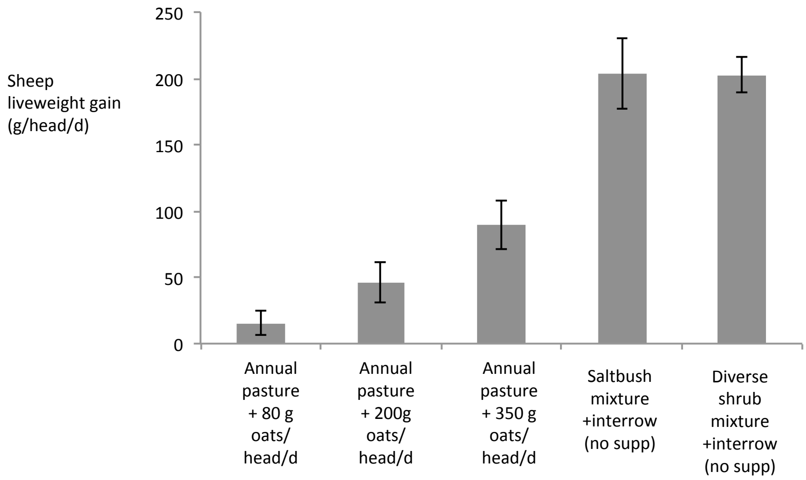


Figure 5. Mean (±SE) liveweight gain of sheep grazing one of five grazing systems: annual pasture with oat grain fed at a level to maintain weight (M), annual pasture with oat grain fed at 200 g/head/d, annual pasture with oat grain fed at 350 g/head/d, saltbush shrubs (selected from productivity) with pasture inter-row, and a diverse mix of shrubs (selected for bioactivity) with pasture inter-row. Neither of the shrub-based treatment received grain supplementation. (K. Lund et al, unpublished data).

6. UTILISING CROP STUBBLES

With the large areas allocated to cropping in most farms across the agricultural regions, crop stubbles could represent a valuable feed resource for backgrounding cattle. There is little recent data on the feed value of cereal crop stubbles in Western Australia (or, for that matter, comparable Mediterranean or temperate climatic zones elsewhere in Australia). Basing predictions on animal performances with older varieties of crops could be misleading because modern cultivars are likely to be more efficient at nutrient translocation from stem and leaf to grain, and modern harvesters are more efficient (i.e. less spilt grain).

Butler's (2014) survey of cropping paddocks is a rare case of recent data on the feeding value of modern crop stubbles. Butler (2014) showed, over two seasons (2002 and 2003), grain residue in cereal stubble paddocks was less than 200 kg/ha (range 7-197 kg/ha), with no correlation between crop yields and grain residues.

In research from over 40 years ago in the ACT, Mulholland et al. (1976) found that sheep were highly selective in seeking green biomass in cereal crop stubbles. In the three years of the experimental work by Mulholland et al. (1976), higher than average summer rainfall occurred, which meant the crop stubbles contained a significant amount of green DM during some of the summer grazing periods. For example, across the three years in February, green DM ranged from about 250 to 1,600 kg DM/ha, whilst dead DM ranged from about 3,000 to 6,000 kg/ha.

When green material exceeded 40 kg DM/ha, the proportion of green material in the diet selected by sheep was about 80-90% (Mulholland et al., 1976). The *in vitro* digestibility of OM of oesophageal fistula samples was about 60%, which equates to about 8.2 MJ ME/kg DM. Sheep may be more selective for 'green pick' than cattle given their smaller mouth and mobile upper lip, but the data nonetheless suggest that livestock will actively seek green components in stubble if it is present.

An implication of the high degree of diet selectivity in crop stubbles is that the quality of the animals' selected diet and their productivity will depend on the amount of green feed available in crop stubbles. In most modern cropping systems, herbicide is used to remove summer weeds, so green feed won't often contribute much to the diet quality of backgrounding cattle grazing crop stubbles. Mulholland et al. (1976) showed that sheep maintained or lost weight when grazing a 'clean' paddock (depending on stocking rate), but could gain weight on 'weedy' stubble. An opportunity for mixed farming systems, therefore, is to avoid herbicide control of summer weeds if cattle were grazing crop stubbles. This would advantage the cattle and reduce costs to the cropping enterprise.

A combination of forage shrubs in triple or quadruple rows in cropping paddocks, with wide inter-row spaces (e.g. 40-100 m) for cropping, is another proposition worth exploring. In such a scenario, the 'green pick' can be supplied by the shrubs, rather than relying on summer rain and pasture/weeds in the crop stubble.

If there is limited grain or green feed in cereal crop stubbles, supplementation with a readily-availably energy source and crude protein (nitrogen) will be necessary because the ME content of cereal stubble is only about 3.5 MJ ME/kg DM (based on *in vitro* OM digestibility from Mulholland et al. (1976) and the crude protein content is about 6%. Pellets based on cereal grain and urea, or lupin grain, should be ideal supplements. The amount required and the cost-effectiveness will be similar to that predicted from the earlier calculations on supplementation to dry annual pasture (Section 4).

To provide an example of cattle performance and the required area of crop stubble to ensure FOO does not limit intake, I have made the following assumptions:

- the selected diet is 10% green feed with an ME content of 8 MJ/MJ/kg/DM, 60% residual grain with an ME of 13 MJ/kg DM, and 30% stubble with an ME of 3.5 MJ ME/kg DM;
- stubble provides 2,500 kg DM/ha and residual grain is 100 kg/ha;
- 80% of residual grain is consumed (remainder is lost due to trampling).

In this scenario, 250-kg cattle would need to be stocked at about 0.5-0.6 head/ha per month. Therefore, 100 cattle would require 180 ha of crop stubble per month, or 720 ha for four months, or 1,080 ha for six months. Weight gain would theoretically be 1.1 kg/hd/day because the assumed diet is 60% grain. However, the energy cost of grazing to consume the dispersed grain, and cattle being relatively inefficient at picking up dispersed grain compared to sheep mean that the growth rate is probably an overestimate. Furthermore, the animals will likely consume the grain first, and the remainder of their time in the stubble paddock will be spent consuming small amounts of stubble (straw) and searching for more grain.

The increasing size of cropping paddocks may actually be conducive to cattle grazing crop stubbles, as long as drinking water is well positioned in paddocks – perhaps at multiple points that can be turned on and off (or moved) so help ensure the animals make full use of the large paddocks during the allocated grazing period.

Tools and methods of 'Self Herding' (Revell et al., 2016) will also be relevant to managing grazing distribution and grazing patterns in large cropping paddocks.

Local studies on the relative proportions of green feed, dry stubble and residual grain are required, combined with data and observations on cattle grazing behaviour, diet selection and liveweight change. A comparison of different supplements is also warranted, such as cereal grain + urea, lupin grain, or canola meal (+/- minerals).

7. WHAT'S NEEDED IN PASTURE RESEARCH TO UNDERPIN A CATTLE BACKGROUNDING SYSTEM

7.1 Plant breeding

Future research needs for annual legumes were identified by Nichols et al. (2012) as developing and releasing cultivars with:

- Greater reliance to declining rainfall and more variable seasons (more on this later in my report)
- Higher tolerance of soil acidity
- Higher phosphorous utilisation efficiency.

Commercialisation of new pastures depends on the size of the market, ease of establishment, and management and health of grazing animals. The WA cattle backgrounding sector will not be large enough in its own right to directly influence plant-breeding programs, but there is an opportunity to incorporate the testing of 'pipeline' cultivars in locations of relevance to cattle backgrounding.

Agronomy and pasture management packages that are directly targeted at cattle grazing should be developed, and aligned with trials and information on animal nutrition and production.

7.2 Interaction with cropping systems

With the likelihood that any increase in cattle backgrounding will come from cropping-dominant farmers, feedbase trials and analysis must include whole-farm **implications**, such as weed management, plant and soil pathogen control from phase farming, and benefits to soil N with the inclusion of legumes in pasture systems.

The increasing incidence of herbicide resistance and the cost of nitrogen fertilisers mean that the economic analysis of backgrounding should include potential benefits to the cropping component of mixed farming systems. This is clearly more relevant where grazing and cropping are in rotation, and less relevant where continuous grazing is deployed on areas not used for cropping.

7.3 Long-term pasture trials

A major piece of missing information is pasture nutritive value and productivity over time (years) for different cultivars or species on a range of soil types. The grains industry provides a good example of ongoing trials to compare cultivars across environments in coordinated G x E trials. A similar approach for pasture evaluation – even if at a much smaller scale than current crop variety trials – would be a major step forward.

Data from co-ordinated pasture evaluation trials could immediately feed into predictions of cattle intake and growth performance. A small sub-set of cultivars should be planted and managed at a larger scale for trials with grazing cattle to validate predictions of intake and growth performance.

Whilst pasture evaluation trials may not seem particularly innovative, if they were combined with trials to generate data on cattle performance, they would add significantly to the confidence in predicting animal growth rates and turn-off weights and dates. Furthermore, preference values (palatability) and pasture regrowth after grazing is determined – if at all – with sheep. We can't always expect the same outcomes with cattle.

A field review of the phosphorus status of tagasaste plantations (and other pasture systems) would be an effective way to determine if higher productivity could be obtained with strategic fertiliser applications. A good example is the data

with tagasaste that showed weight gain per hectare continued to increase up to 400 kg of superphosphate/ha/year over 5 years, even though plant productivity responses ceased at a lower rate of fertiliser application. In such cases, it may be more cost-efficient to provide the additional phosphorus as a feed supplement directly to the animals.

A field experiment to compare nil fertiliser vs fertiliser vs mineral supplementation directly to the cattle would resolve this issue. It should also quantify the economic value of phosphorus application at current prices. This work is even more necessary given that pastoral cattle arriving at backgrounding farm may be low in phosphorus reserves since large areas of WA's pastoral regions are phosphorus deficient, and not all pastoralists will be supplementing with phosphorus prior to sending cattle south.

Based on the nutritive value of rangeland plants (D.K. Revell, unpublished data), pastoral cattle may respond to supplementation with phosphorus, sulphur, sodium or magnesium, depending on their origin.

7.4 Mixed forage systems

To reliably reach targeted growth rates across years, with different rainfall patterns and ambient temperatures, I would contend that a combination of forage species is essential. Mixed forage systems can add to the perceived complexity to the farming system, but forage mixtures can be provided a 'true' mix or spatially separated.

Spatial separation may be easier to manage if the plants have different requirements, e.g., for fertiliser, pathogen control, or recovery time after grazing. Feed intake and animal productivity can be improved when different plant species are spatially separated (see review by Rutter 2006), presumably because the animals can more efficiently select a combination of plants that best meets their nutritional and metabolic requirements.

Even with spatial separation, however, it is important that animals can 'mix and match' plant species within each day or grazing, rather than being rotated between pasture types every, say, week. In a trial with sheep at Badgingarra (Revell et al., unpublished data), rotating animals between stands of tagasaste, *Rhagodia preissii* and old man saltbush (*Atriplex nummularia*) every 5 days lead to fluctuations in body weight, with no net gain after one month of grazing. In comparison, having access to these three shrub species simultaneously led to an increase in weight gain. Such trials with cattle have not, to my knowledge, been done in WA, but would be very worthwhile.

Recently published data from a nine-year trial in the USA (Skinner and Dell, 2016) showed that pasture biomass production was greater with a 5 species mixture compared with a 2 species mixture. When averaged across years, the five-species mixture produced 31% more forage biomass than the two-species mixture. The species used in this study were chicory, orchardgrass, tall fescue, white clover and lucerne. Trials with species relevant to WA conditions and in WA soils are required. A potential benefit in forage biomass in the order of 30% is considerable, plus the profile of nutrients available to grazing livestock will likely be better as well, the species will have different rooting depths and each will have its own nutritional profile.

7.5 Forage shrubs

The major gaps in knowledge that are limiting the wider use of native shrubs as part of a cattle backgrounding system include:

- Reliable, low-cost establishment

(direct seeding is not always effective; seedling planting can be expensive);

- More data on cattle performance rather than relying on an extrapolation from sheep;
- Identifying the best pasture-shrub combinations for cattle
- Testing if the provision of native shrubs at a backgrounding farm can help pastoral cattle familiar with browsing native shrubs better adapt to relocation.

7.6 Choice of supplementation

The example of lupins supplementing tagasaste (Section 5.3.2.1) highlights the opportunity for improving cattle performance when the forage quality limits growth rate. The decision on the best of supplement should take into account animal performance, impact of the supplement on total feed intake, pasture intake (i.e. positive associative effects or substitution effects) and cost of production. This suite of information for different supplements is actually very scarce; as McLennan et al. (2017) stated "information on the marginal efficiency of supplement utilisation [with poor quality forages as the base diet] is generally not available".

McLennan et al. (2017) compared sorghum, barley or molasses-based supplements and found marked differences in the efficiency of converting supplement DM intake to daily gain. Based on their data, I calculate that for a 300 kg animal (*Bos indicus* crossbred steer), every kilogram of supplement would increase LW gain by 0.19, 0.23 or 0.29 kg/head/day with a molasses, sorghum- or barley-based supplement (respectively).

McLennan et al. (2007) found that supplementation increased total intake and reduced the intake of poor quality Rhodes grass hay that they used as the base diet. Importantly, the efficiency of converting ME consumed to energy retained by the steers (i.e. body tissue) varied by up to one-third between the different supplements. This is a considerable difference that could have a major effect on profitability of a backgrounding enterprise, given the importance of cost of production and conversion efficiency in a production system with tight margins.

What's needed are data on animal responses to different types of supplement and different rates of supplementation for our Western Australian circumstances. The supplements to be compared should include:

- lupins
- canola meal
- barley, oats, wheat
- +/- urea
- good quality alkalage, silage or hay

"The choice of supplement for cattle will be based on the growth response to correcting ... limiting nutrients, the relative cost of providing them in a commercial supplements and the practicalities of delivering them under extensive grazing conditions." (McLennan et al.,2017), Furthermore, the optimal supplement will depend on the base pasture or forage being used at any given time (e.g. senesced annual pasture, perennial grasses, tagasaste or native shrubs).

8. AREAS OF PASTURE REQUIRED TO UNDERPIN A BACKGROUNDING SECTOR AND EXPECTED PRODUCTIVITY PER HECTARE

With a diverse forage base of annuals and perennials designed to minimise the need for supplementary feeding, the area required per 100 head of cattle range from 25-90 ha, depending on the forage being used in any given month, the duration of feeding that forage, and the region (Table 4).

The total area of pasture over the 11 months of the modelled case studies required for 100 cattle needed from 120-225 ha, which is equivalent to an average stocking rate of 0.4-0.8 animals per ha. However, during periods of feed abundance, the stocking rate was up to 4 animals/ha.

Table 4. The area of annual pasture, perennial grasses, shrubs and crop grazing required by 100 head of cattle for food on offer to not limit feed intake during the allocated months of grazing period.

	Annual pasture		Perennial grass		Shrubs		Crop		Total
	ha	months per yr	ha	months per yr	ha	months per yr	ha	months per yr	ha required/ 100 hd
Northern	30	6	40	3	40	2	50	1	160
Central	25	6	25	2	75	3	75	1	200
Southern	40	6	20	3	60	3	-	-	120
Eastern	55	7	-	-	80	4	90	1	225

Productivity per hectare, based on the total area required for the duration of grazing (11 months), ranged from 97-182 kg/ha/year (calculation A in Table 5). This is not particularly impressive, especially considering that it includes some level of supplementary feeding, but it is the average over a year, which includes the drier months where pasture growth rates are low.

It may be more appropriate to calculate productivity based on the area excluding the area of crop grazed in winter because grazing a winter crop does not remove that area from the cropping program (because it is dual purpose) – calculation B in Table 5. Productivity calculated this way is about 50% higher than by method A: from 162-198 kg/ha/yr, depending on the region.

Similarly, it may also be useful to calculate productivity excluding both the area of crop grazing and the area allocated to shrubs, because the parts of a farm planted to shrubs are likely to have a low opportunity cost (i.e., shrubs tend to be grown when other land-use options are limited and cropping is considered not economically viable) (calculation C in Table 5). Productivity calculated this way is 3-4 times higher, at 311-436 kg/ha/year, than by method A.

I suggest that method B (i.e. excluding any area used for winter crop grazing) will be the most appropriate for most situations.

Table 5. The total area required for 100 head of cattle, expressed with or without shrub and crop components, and productivity expressed as kg weight gain/ha/year.

	A		B		C	
	Total area required (ha)	Productivity (kg weight gain/ha/yr)	Area required excluding crop (ha)	Productivity (kg weight gain/ha/yr) – excluding crop area	Area required excluding shrubs and crop (ha)	Productivity (kg weight gain/ha/yr) – excluding shrub and crop
Northern	160	136	110	198	70	311
Central	200	109	175	175	50	436
Southern	120	182	182	182	60	363
Eastern	225	97	162	162	55	397

The potential additional number of 350 kg steers that could be reared in the agricultural regions was proposed in a recent report by DAFWA (2016), "Production potential within the Western Australian beef industry". The number approached 20,000 for each the northern, central and southern regions (Table 6) .To meet the ME requirements for the additional cattle to grow at the target of 0.6 kg/head/day, an additional 14,000-16,000 ha of perennials (grasses and shrubs combined) would be needed in each of the northern, central and southern regions.

There were no estimates in the DAFWA (2016) report of a potential increase in carrying capacity in the eastern wheatbelt, but if we assumed a conservative value of an extra 5,000 head, that region would need and extra 4,000 ha of perennials, most likely shrubs due to the limited current options for a productive perennial grass in the drier parts of the wheatbelt.

As a guide to the number of farms that would be needed to grow the extra perennial feed for the extra cattle, I have assumed a typical farm will have 100 ha of perennials. This is based on a survey by Moore (2013), which showed the area of perennial grasses averaged 63 ha per farm for northern sandplain farmers. It is also consistent from whole-farm economic modelling that has indicated maximal whole-farm profit was achieved with 10-15% of a farm area allocated to perennials (Bathgate and Pannell, 2002; Monjardino et al., 2010).

Assuming 100 ha of perennials per farm, there would need to be an extra 100-160 farms in each region to supply the ME required to meet the 'potential additional number of cattle'. An alternative model is for farms to convert to predominantly backgrounding operations. Either system seems an unrealistic goal in the short- to medium term, without a coordinated effort of research, demonstration and on-going support.

For whole-of-industry planning, it is essential to validate the true potential for each agricultural region to background additional cattle, beyond current capacity. The validation should be based on:

(i) farmer surveys to gauge interest and capacity, areas suitable for perennial forages, and time frames required to build up capacity, and

(ii) data on forage productivity over time.

Table 6. Estimated area required of the different forage types to meet the feed demand of the potential additional number of steers growing at 0.6 kg/head/day, based on the prediction in the DAFWA report. The allocation of area to the different forage types is based on the modelled scenarios described in this report.

		Approximate area (ha) required to meet the feed demand of the predicted extra carrying capacity			
	Potential additional number of growing steers	Annual pasture	Perennial grass	Shrubs	Crop grazing
Northern	19,850	6,000	8,000	8,000	10,000
Central[1]	10,000	3,750	3,750	11,250	11,250
Southern	17,652	7,000	3,500	10,500	-
Eastern[2]	5,000	3,000	-	4,000	4,500

[1]To confirm this figure for the central region (a page was missing from the copy of the report I have seen).
[2]There were no predictions for the eastern wheatbelt in the DAFWA report, so I have used figure of 5,000 head.

The cattle industry in WA would be well served by establishing and supporting a coordinated network of backgrounders, which could number more than 100 farmers in each region. An association or other membership-based organisation could help share information and coordinate activities. Such a group may not need to be formed from scratch, but rather from existing producer groups.

Regardless of the structure, a forum dedicated to cattle backgrounding in WA, linking cow-calf production to the finishing, processing and marketing sectors is recommended. The scale of opportunity, and the scale required for a reliable backgrounding sector that, as a whole, can tolerate variable seasonal conditions, means the industry should be actively working to build awareness and growth.

Building knowledge and capacity in feedbase management will be central to success. Without systems consisting of peer support, R&D, and continuous collection of relevant data with efficient feedback of information, it is unrealistic to expect a cattle backgrounding sector of critical mass to evolve on its own.

9. ECONOMICS OF THE FEEDBASE AND COST OF PRODUCTION

The cost of pasture establishment and maintenance was estimated from published values or from personal communication with experienced industry personnel. To calculate an average annual cost, the establishment costs were amortised over 5 years for all pastures except shrubs, which were amortised over 10 years. This is a conservative estimate of the 'lifespan' of pastures and shrubs, but allows for changes in paddock use associated with mixed farming systems. It is likely, however, that areas planted to shrubs would not be used for cropping and a 20-year lifespan would be a reasonable expectation. Nevertheless, I have used 5 and 10 years (for pasture and shrubs) in this report.

Land values and opportunity costs are <u>not</u> included in the simple economic analysis that follows. Pasture establishment costs includes labour, but no other labour expenses are included. Additional costs such as fencing and establishing new water points are also not included, as these costs will vary considerably between individual enterprises.

The purpose of the economic analysis is to determine the expected cost of feeding (pasture + supplements) to produce 1 kg of weight gain, within the context of the modelled case studies.

The full set of results for the estimated costs of production for the different scenarios I modelled are shown in Table 8, on the last page of this report.

9.1 Cost of forage establishment and management

Establishment and maintenance costs for the forage options and the supplementary feeds are listed below in Table 7. The annual cost of the pasture options when amortised over 5 years were $70-82/ha, and shrubs amortised over 10 years was $91/ha.

A system based on annual pasture and supplement (such as hay) avoids the cost of establishing perennials. So, which is the best way to go? Spend money to improve the feed base and minimise supplementary feeding, or avoid the up-front establishment cost of pasture improvement and use more supplementary feeding? Expressing costs per kg of weight gain is a useful way of comparing the two systems.
Using amortised annual costs, the cost of producing 1 kg of liveweight gain with a forage system of annuals and perennials, including the necessary supplementation to reach the targeted weight gain, was $1.02-1.57/kg LW gain. This is 20-36% less than the cost of production with annual pasture (no perennial pasture) supplemented with hay: $1.45-1.95/kg LW gain.

If the pasture establishment costs were allocated against year 1 only, rather than being amortised over 5 years (or 10 years for shrubs), the cost of production in the first year would be $2.00-3.78/kg LW gain. If costed in this way, it would be cheaper using hay as a supplement to an annual pasture system (cost of production of $1.70-2.32/kg LW gain.) However, if this approach of using hay to supplement annual pasture were to be continued for more than just one year, it would become more expensive than developing an improved pasture system that included perennials.

The estimated cost of lupin supplementation with an annual and perennial forage system is $45-136/head. If hay is used to supplement annual pasture (i.e., if no perennial forage is available), supplementation costs more than double to $260-353/head.

Table 7. Estimated cost to established and maintained the different pasture and forage options, and the supplements lupins or hay.

	Establishment cost of pasture ($/ha) or cost of supplements($/tonne)	Annual maintenance cost ($/ha)	Annual cost amortised over 5 years, or 10 years for shrubs ($/ha)
Annual pasture	210	40	74
Lucerne	250	40	82
Perennial grass	210	40	74
Shrubs	550	40	91
Crop	70[1]	-	70
Lupins (supplement)	350	-	-
Hay (supplement)	280	-	-

[1] I've assumed 20% of crop input costs of $350/ha is attributed against the winter grazing of cereal crop

9.2 Return on investment

The price per kg of LW gain that is required to recover forage establishment costs in one first year is between $2.00 and $2.92 for the northern, central and southern regions, and $3.78 for the eastern wheatbelt. At a price of $2.40/kg liveweight gain, the time taken to recover establishment costs is therefore about 1-1.5 years; 1.04, 0.83 and 1.22 years for the northern, central and southern regions, respectively, and 1.57 years for the eastern wheatbelt.

A return on investment takes longer for the eastern wheatbelt because of a higher reliance on shrubs as the perennial forage option. More hectares of perennial shrubs are required in the eastern wheatbelt than the other regions, there are few other perennial forage options and shrubs (or any other perennial if another is available) will be needed for 4 months of grazing each year.

If hay was used as a supplement to annual pasture (and hay cost $280/tonne), the required price/kg LW gain to recoup feed costs is $1.70-1.77 for the northern central and southern regions, and $2.32 for the eastern region. If the price paid for one kilogram of weight gain was $2.40/kg LW gain, a simple system of annual pastures and hay would cover feed costs in all regions, but only just in the eastern wheatbelt scenario. Even in the northern, central and southern regions, the margins would be extremely tight once additional costs of fencing and water, and overhead costs of rates etc., were included. Therefore, relying on annual pasture and hay supplementation is not a long-term strategy, but could be used tactically for short periods to get through difficult periods, such as poor perennial forage production or a short-term increase in the number of cattle that a backgrounder agrees to manage.

9.3 Gross margin per ha

Using feed (forage + supplements) as the only cost of production (i.e. excluding labour and overhead costs), the calculations for the four regions with a diversified feed base consisting of annual and perennial forages showed that cattle backgrounding is profitable.

Using a productivity value of 180 kg liveweight gain/ha/year (the average across regions using method B, Table 4), and an average cost of production of $1.20/kg liveweight gain, the cost of production per hectare equates to $216. At a price of $2.40/kg liveweight gain, income equates to $432, with a gross margin of $216/ha.

Using a productivity value of 131 kg liveweight gain/ha/year (which is the

average across regions using method A; Table 4), the gross margin would be $157/ha.

A gross margin of around $200/ha is competitive with recent calculations of gross margin for cropping in the medium rainfall zone of the southwest of WA (Figure 6). However, the GM of any enterprise varies widely between different farms, as evident by the spread shown in Figure 6 for cropping. There is no substitute for collecting the necessary data and calculating productivity and costs of production for each specific circumstance.

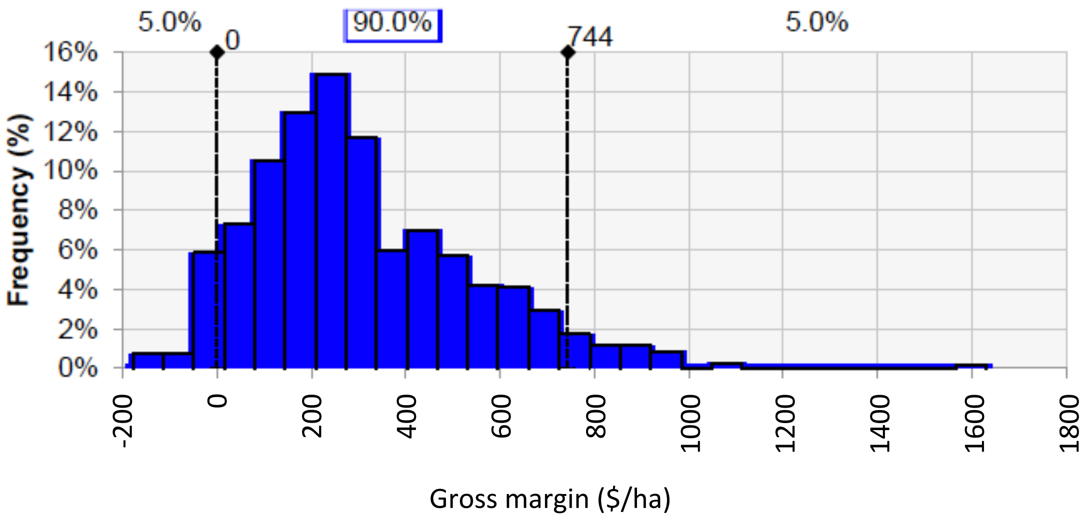


Figure 6. Paddock gross margins 2010-2014 in cropping systems. Source – Hagan (2016).

10. WHAT ELSE MIGHT IS NEEDED TO MAKE A CATTLE BACKGROUNDING SECTOR MORE ATTRACTIVE TO NEW ENTRANTS?

10.1 Economics, climate and the future feed base

The calculations documented in Section 9 in showed that a pasture-based backgrounding system that requires up-front expenditure to establish a mix of annual and perennial forages can produce a kilogram of weight gain for about $1.00-1.50, depending on the region. This is an average figure, and does not take into account seasonal variations that may require, for example, a higher requirement for supplementary feeding to cover an extended dry period.

In developing a new or expanded WA backgrounding sector, it is critical to consider risk in managing seasonal fluctuations. The choice of forages used in the feed base is one important component in determining seasonal risk.

There is a lesson from the push to expand the sheep numbers in WA about 10 years ago. Some producers did re-invest in sheep, but a drought year in 2010 seriously challenged a lot of sheep operations.

Unless industry development and promotion occurs in parallel with strengthening the underlying capacity and resilience in the feed base, it will be very difficult to sustain growth in a livestock enterprise, including cattle backgrounding.

Modelling (Bell et al., 2012) of sheep production under future climate scenarios in southern Australia suggests that where existing pasture species become less productive under drier and warmer conditions, pasture intake will be reduced and there will be an increased reliance on supplementary feed in an attempt to maintain production levels. Where forage species can tolerate warmer and drier conditions, the reverse is predicted (i.e. a reduction in supplementary feeding). This affirms that we should be placing greater effort in developing robust forage systems that are designed with the changing climate of southwestern Australia in mind.

One challenge to animal nutrition is that plants that are tolerant to difficult conditions, including drought, tend to have a lower feed value due to higher fibre content (especially the acid detergent fibre fraction) or the presence of secondary plant compounds that can impair rumen fermentation. However, there are four positive factors to consider in this scenario:

1. The comparison in nutritive value between ‘tolerator plants’ (e.g. perennial shrubs) and ‘conventional’ pasture plants (e.g. annual legumes) should be made at the time of year when the tolerator plants are to be grazed, which in most situations will be in summer and autumn when senesced annual pasture species are of lowest quality, or in early winter when annual pastures tend to have low biomass. In these comparisons, the tolerator species can be seen as highly valuable additions to the feed base.

2. The presence of secondary compounds has been associated with improvements in quality of ruminant

products (Vasta and Luciano, 2011), such as meat odour and shelf life.

3. Some secondary compounds can have positive bioactive properties that modify rumen fermentation profiles such as reducing methane production (Durmic et al., 2013), especially with lower concentrations in the diet that occur with a mixed diet.

4. Maintaining diet diversity can reduce the consumption of anti-nutritional factors associated with any individual forage species. Cattle are able to tolerate different secondary compounds, such that feed intake need not be compromised if different plants with different secondary compounds are consumed (Villalba et al., 2004). In fact, a broad selection of plants can actually stimulate feed intake. In a study of shepherded livestock expose to a diverse diet in France, feed intake was nearly double the predicted level (Meuret and Provenza, 2015), a phenomenon attributed to a combination of nutritional and behavioural responses of animals to a wide range of plants in their diet. I propose that increasing diet diversity is one of the most under-utilised management strategies available to us.

10.2 Data on 'Accelerated Adaptation' of pastoral cattle entering a backgrounding system

The key management practices to prepare animals for transportation and receiving animals at a new location have recently been collated in a manual, 'Practices and Procedures for profit, efficiency and livestock welfare along the WA beef value chain' (Revell and Maynard, 2017) for the Mingenew Irwin Group, as part of their current Grower Group R&D project. The manual summarises the main scientific findings and includes new practices for a 'behaviourally-enhanced' supply chain.

Previous research in WA has shown the potential to increase pasture intake and the rate of weight gain of pastoral cattle with behaviour-based management (Thomas et al., 2010; 2011). A project with sheep (Bickell, 2014) showed that applying methods to de-stress animals upon arrival to a feedlot could increase growth rates in the feedlot by up to one-third. There is no reason why similar benefits could not be expected for cattle entering a backgrounding system because the underlying principle is that when animals face a large change in their surroundings, they can adapt more quickly if 'guided and supported' by behaviour-based management.

The developments from Rangelands Self Herding (Revell et al., 2016) have created the opportunity for even better improvements in cattle performance after relocation from the rangelands to backgrounding farms. Observations of pastoral cattle exposed to a procedure called 'Accelerated Adaptation' have shown noticeable improvements in animal behaviour, with rapid adjustment by the animals to their new surrounds. What remains to be done is to quantify these benefits in terms of growth rates and profitability, in different locations and on different pastures. Potential improvements to meat quality associated with better animal management and nutrition along the supply chain should also be assessed.

10.3 The need for medium-term certainty in a profitable backgrounding sector to encourage investment

For producers to embark on a program of pasture improvement and incorporate perennial forages into the feed base on their farm, they will need to be confident on the long-term viability of a backgrounding sector. Historically, fluctuating prices of cattle and feed have meant that the red meat supply chain has tended to favour either producers or processors.

For a coordinated backgrounding sector to flourish, new partnerships, alliances or dedicated supply chains are required so the industry as whole can tolerate fluctuations and minimise risks. Backgrounding operations will need to keep their cost of production as low as possible, which means having an efficient forage system and minimising supplementary feeding.

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Table 8. Calculated costs of production for the different modelled scenarios. The rows in blue are the scenarios where the target weight gain of 200 kg is achieved.

	Ha or tonnes per 100 animals	Cost of system - annual average ($/100 animals)	Establishment cost of system ($/100 animals)	Weight gain per head (kg)	Average annual feed cost$/kg LW gain	Establishment year feed costs ($/kg LW gain)	Years to recover establishment cost - at $2.40/kg LW gain	Price required to recover establishment costs in 1 year - at $2.40/kg LW gain
Northern								
Annual pasture	30	$2,220	$6,300	69	$0.32	$0.91		
+ perennial grass	40	$5,180	$14,700	96	$0.54	$1.53		
+ shrubs	40	$8,820	$36,700	120	$0.74	$3.06		
+ crop grazing	50	$12,320	$40,200	141	$0.87	$2.85		
+ lupins to reach target	30	$22,820	$50,700	203	$1.12	$2.50	1.04	$2.50
Annual pasture + hay to reach target	99	$29,940	$34,020	200	$1.50	$1.70	0.71	$1.70
Central								
Annual pasture	25	$1,850	$5,250	64	$0.29	$0.82		
+ shrubs	75	$8,675	$24,000	99	$0.88	$2.42		
+ lucerne	25	$10,725	$30,250	153	$0.70	$1.98		
+ crop	75	$15,975	$35,500	174	$0.92	$2.04		
+ lupins to reach target	13	$20,385	$39,910	200	$1.02	$2.00	0.83	$2.00
Annual pasture + hay to reach target	108	$32,006	$35,406	200	$1.60	$1.77	0.74	$1.77
South coast								
Annual pasture	40	$2,960	$8,400	80	$0.37	$1.05		
+ perennial grass	20	$4,440	$12,600	96	$0.46	$1.31		
+ shrubs	60	$9,900	$45,600	127	$0.78	$3.59		
+ lupins to reach target	39	$23,550	$59,250	203	$1.16	$2.92	1.22	$2.92
Annual pasture + hay to reach target	93	$29,084	$34,524	200	$1.45	$1.73	0.72	$1.73
Eastern								
Annual pasture	55	$4,070	$11,550	64	$0.64	$1.80		
+ shrubs	80	$11,350	$55,550	105	$1.08	$5.29		
+crop	90	$17,650	$61,850	128	$1.38	$4.83		
+ lupins to reach target	39	$31,300	$75,500	200	$1.57	$3.78	1.57	$3.78
Annual pasture + hay to reach target	124	$38,930	$46,410	200	$1.95	$2.32	0.97	$2.32