

Ten issues to consider when addressing the balance between feed supply and demand – a discussion paper for Grain and Graze

The national feedbase project team

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A central concept in the Grain and Graze program is the management of the feedbase on mixed farms to maximise productivity and profit in the livestock and cropping enterprises. Management of the feedbase is sometimes encapsulated in the idea of balancing feed supply from pastures, forages, crops and crop stubbles with the metabolic needs of livestock. This balance can be summarised as feed supply and demand curves (Fig. 1).

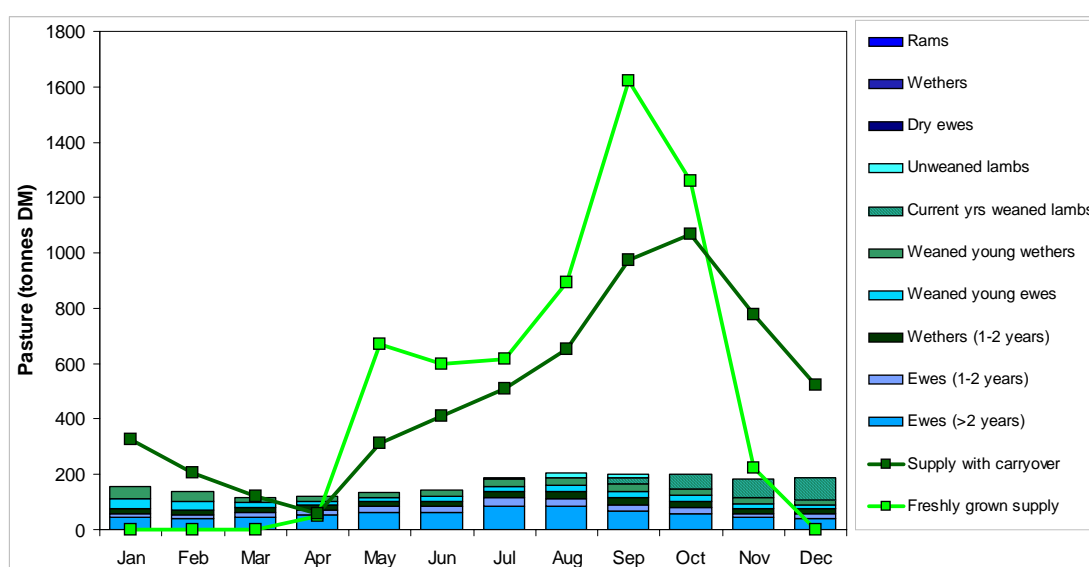


Figure 1: A typical presentation of feed supply and demand curves. Example output from the MLA Feed Demand Calculator.

The existence of gaps between supply of newly-grown forage and the daily demands of livestock suggests that there are inefficiencies in the system, both in terms of excess feed wasted and unmet animal demand. The need to “close” this fed gap/excess is seen as a major challenge for improving the productivity of livestock in mixed farming systems. A number of tools (such as the MLA Feed Demand Calculator) are available to help summarise, analyse and visualise feed supply and demand through the year, and such tools are being used across Grain and Graze.

In this document we set out some principles that we believe are important when thinking about supply and demand of feed on farms, and provide guidance on how such issues should be analysed and solved. These principles have implications for how tools such as the MLA Feed Demand Calculator can be used effectively. They also have broader implications for devising better management of the feedbase on mixed farms.

We have distilled our principles into ten key messages:

1. A feed gap is defined by economics, not biology
2. Feed gaps can be corrected by altering either feed demand or supply, but we must consider both simultaneously
3. Metabolizable energy should be used to compare feed supply and demand curves
4. Annual pasture utilisation is not a particularly useful metric for assessing changes in the balance between feed supply and demand
5. The assessment of imbalances between feed supply and demand are heavily influenced by whether we assess feed supply by monthly (or weekly) pasture growth rates, or if we include some pasture carryover
6. When considering the benefits of matching livestock demand with supply the lag effects on animal performance should be considered
7. Depicting feed supply and demand curves as seasonal averages will tend to overstate the potential gains that can be made by using more of a feed surplus and understate the potential gains of closing a feed gap
8. Large variations that exist between years mean that average regional differences should not be overstated
9. Tactical versus strategic changes to feed supply; 'horses for courses'
10. The value in feed supply and demand concepts for grazing managers lies in being able to monitor the status of their system at any point in time and so being in a position to anticipate and respond to shortfalls in supply.

1. A feed gap is defined by economics, not biology

Feed gaps exist on-farm because it is not a straightforward exercise to fill them. There are often environmental issues, social implications, or structural adjustments to the farming system that limit the capacity to reduce a feed gap. New technologies and ideas become available, but always with some initial cost to implement. The acceptable cost of making a change depends on the likely financial return from the grazing enterprise. In some cases, it will be more profitable to increase inputs to boost supply and subsequently boost animal production, but in other situations, it may be more profitable to maintain or even reduce inputs if it saves more than can be recouped from animal production.

What this means: The biology of pasture and animal production needs to be coupled with an economic evaluation.

A convenient integrative measure of the economics of the feed gap is the marginal value of feed throughout the year (Fig. 2). This quantifies the value of an extra kg DM or MJ of metabolizable energy to whole-farm profit. Fig. 2 shows that this marginal value will vary with the livestock enterprise as well as many other factors.

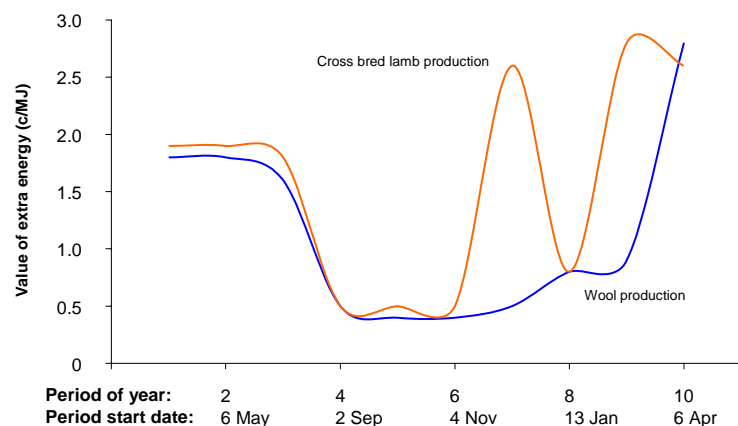


Figure 2: Marginal value of additional energy for a wool flock and a cross bred flock at different times of the year. Data from the Central wheatbelt WA version of MIDAS (courtesy Andrew Bathgate).

2. Feed gaps can be corrected by altering either feed demand or supply, but we must consider both simultaneously

A feed gap is a function of both supply and demand. So in assessing options to modify the feed supply, there are three key questions that link both supply and demand:

1. What is the cost of the current situation? In other words, how severely is feed supply limiting the profitability of the animal production system (see issue 1)?
2. If I improve the feed supply curve, how will I use it to ensure that I can more than cover the cost of implementing the change?
3. Might it be easier and/or cheaper to alter animal demand, rather than fighting against environmental (or climatic) constraints to pasture growth?

What this means: The planning process to address feed gaps should be an iterative process between altering supply and modifying demand.

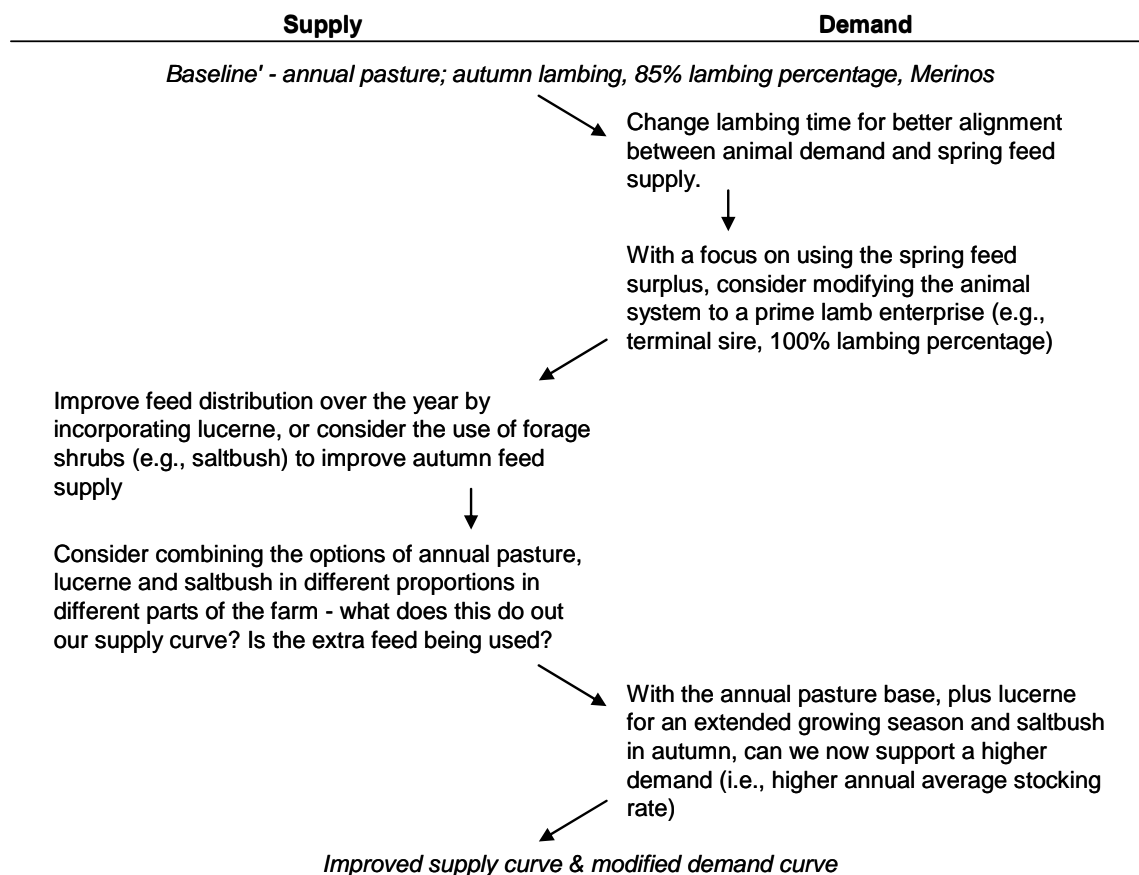


Figure 3: A schematic example of an iterative set of considerations involving both feed supply and demand. For each step, the MLA Feed Demand Calculator (or other tools) could be used to indicate the broad changes that occur as a consequence of each step.

There is a tendency for us to consider the feed gap mostly in terms of altering the feed supply rather than feed demand. Table 1 shows that the management options being considered across the Grain and Graze regions are mainly those concerned with altering supply.

Table 1: Tactics being investigated across the Grain & Graze regional projects for improving the utilisation of energy supplied from pasture and/or reducing feed gaps.

	Improve current system	Change livestock system	Forage cropping	Summer perennials	Supplementary feeding/ feedlotting	Utilising crop residues	Feed conservation
Northern Agricultural		✓ trading stock		✓ sub-tropical grasses (✓)			
Avon	✓ stocking rate						
Eyre Peninsula			✓ grazing cereals		✓ feedlotting	✓	
Mallee	✓			✓ lucerne, saltbush	✓		
Corangamite/ Glenelg-Hopkins	✓ N fertilizer		✓ grazing cereals	✓ lucerne, native grasses		✓	
Murrumbidgee			✓ grazing cereals other annuals	✓ have lucerne		✓	
Central West/ Lachlan			✓ pasture cropping	✓ saltbush			
Border Rivers					✓		
Maranoa-Balonne			✓ forage oats, some annuals	✓ lablab, burgundy bean			

The emphasis in Grain & Graze on on modifying feed supply rather than altering demand probably relates to the following factors:

- Within a region, there are limits to how economic or easy it is to tactically trade livestock or de-stock/re-stock readily in response to changes in feed supply. As well as regulatory constraints (e.g. Ovine Johnes disease regulations), price movements act as a disincentive to trading: when stock are in demand, prices will be high and conversely at times of de-stocking. Such trading strategies will probably work well where there is geographical separation between the sinks and sources of livestock, or enterprise separation e.g. feedlotting vs. grazing.
- There are potentially greater financial risks (perceived or real) associated with a change in livestock demand compared to altering supply, due to the increased pressure and cost of dealing with an excess in demand when the situation arises (see point 7).

When considering a change in one component of the feed supply and demand mix on a farm, whole farm issues have to be considered. Improving the amount or quality of one component of the feedbase may have consequences for another component. For example, use of perennials to fill summer-autumn feed gaps may allow deferred grazing of annual pastures elsewhere on the farm, with the result that the amount, timing and quality of feed from annual pastures is improved. On the other hand, dealing

with a feed gap at one time of the year may generate a new feed gap at another time of the year. Increasing the area of lucerne on a mixed farm may improve spring-summer-autumn feed supply but reduce the feed supply in the winter, with the result that the stocking rate a farm can carry through the winter will be limited.

3. Metabolizable energy should be used to compare feed supply and demand curves

A change in feed supply can be expressed in terms of how much change it would have on animal production. For example: if feed supply were doubled, how many more dry sheep equivalents could be run per hectare, or how much faster would the animals grow?

What this means: The best way to evaluate the potential impact of a change in feed supply on animal production is to express both feed supply and demand in common units. Since livestock are most often limited by their energy intake, the best common unit is metabolizable energy (ME). ME is the energy that animals can use for productive purposes.

Figure 4 shows pasture supply curves for four regions expressed in energetic terms, and compares these values with the energy requirements for various levels of animal production. This type of comparison allows us to evaluate the 'worth' of a certain level of feed supply in terms of the animal productivity it should be able to sustain.

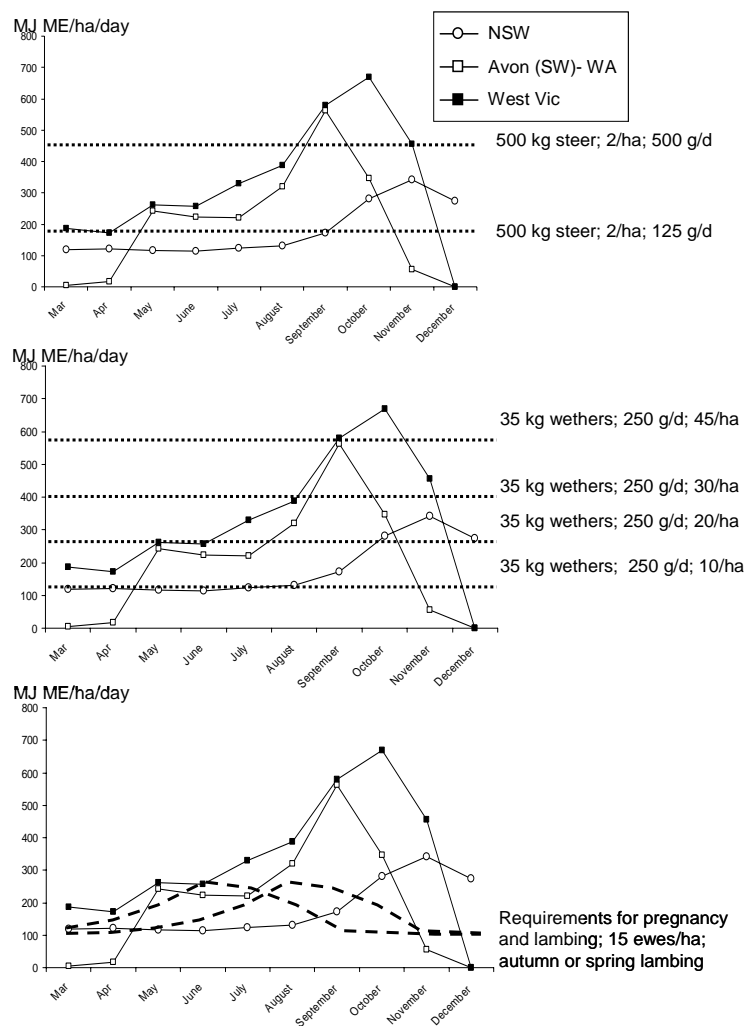


Figure 4: A comparison of feed supply and animal demand scenarios, with both supply and demand expressed in the common currency of metabolizable energy (MJ ME).

An alternative common unit for standardising across feed supply and demand is “dry sheep equivalents”, or DSE. Stock in any physiological state can be expressed relative to 1 DSE and pasture supply could be expressed in terms of how many DSE it could sustain. There are, however, differences from state to state in the reference “dry sheep” against which DSE values are calculated; ME units do not suffer from this disadvantage.

DSEs can be related quite closely to amounts of ME. For example, by using the Australian feeding standard it can be calculated that in New South Wales, one DSE is equivalent to 8.8 MJ/d of ME.

4. Annual pasture utilisation is not a particularly useful metric for assessing changes in the balance between feed supply and demand

Pasture utilisation is the amount of forage eaten over a time period divided by the amount grown in the same period. It is a summary measure of the intensity with which a piece of land is grazed.

The long-term annual utilisation rate on a farm will only change markedly in response to large alterations in the stocking rate or a major alteration to soil fertility. Equally major changes in the livestock enterprise type or the suite of pasture types only produce small shifts in the annual utilisation rate.

For example, using the MLA Feed Demand Calculator in a series of scenarios for the Avon region (full details of the scenario testing will be reported in due course), we changed from autumn lambing with a lambing percentage of 85% to spring lambing with a lambing percentage of 110%, while holding constant the amount of live weight produced per hectare. Overall pasture utilisation did not change; it was 34% for both cases. Subsequently changing 20% of the pasture area from annual pastures to lucerne (and using average values for lucerne growth), again holding liveweight production per hectare constant, reduced overall utilisation by only 3 percentage units to 31%.

In reality, large changes in stocking rate or annual feed supply are not easy because of environmental constraints; after all, a gap will exist because it hasn't been easy or cost effective to change practices previously. New technologies, including new pasture varieties, can improve this capacity to implement a change.

Changes that are quite modest in the context of pasture utilisation over a full 12-month period can nonetheless have a considerable impact on profitability and/or riskiness.

What this means: When planning for changes to improve the balance between feed supply and demand, we must identify ‘trouble-spots’ and quantify changes in pasture utilisation at these particular times.

To more easily identify changes in pasture utilisation on a monthly basis, we suggest presenting utilisation rates on a logarithmic scale. This will

- ‘stretch’ the differences between values when pasture utilisation is less than 1 (ie, when supply exceeds demand) and thus help to highlight numerically similar values that are quite different in terms of the underlying biology or farm management practices (e.g., utilisation rates of 0.25 vs 0.30);
- reduce the differences between values when pasture demand exceeds supply (e.g. if demand was 20 kg DM/ha/day, and supply changed only subtly from 5 to 1 kg DM/ha/day, as it might in autumn in a Mediterranean climate, utilisation (i.e, demand/supply) would change from 4 to 20. On a logarithmic scale, values above 1 are not so visually divergent.

Figure 5 shows an example for the Avon (WA) region with different scenarios of feed supply. The data are expressed as month-by-month feed utilisation as described above. In all cases, the annual pasture utilisation rate was 30-34%, but differences in month-by-month utilisation rates can be clearly seen. The different strategies have varying degrees of success in reducing the feed gap in March and April (seen by the different peak heights at this time of year, where demand can often exceed supply as evidenced by a utilisation value above 1.0).

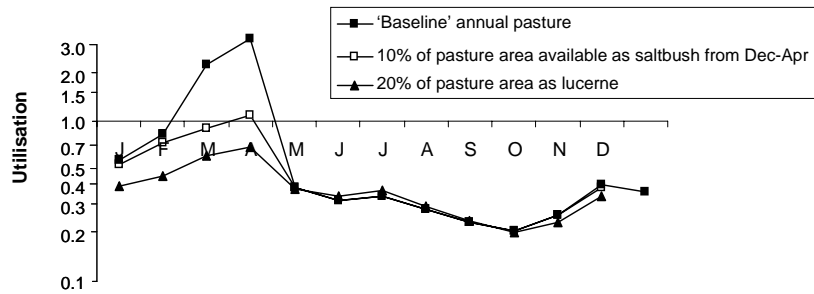


Figure 5: Pasture utilisation (expressed on a logarithmic scale – see text for details) for four feed supply scenarios in the Avon region, using the MLA Feed Demand Calculator and published values for pasture growth rate.

5. The assessment of imbalances between feed supply and demand are heavily influenced by whether we assess feed supply by monthly (or weekly) pasture growth rates, or if we include some pasture carryover

We tend to think about pasture supply in terms of daily pasture growth rates. The figures above, for example, report daily growth rates averaged on a monthly basis. Animals, however, will eat pasture that was grown some time in the past if there is not sufficient new, high-quality pasture, and so “carryover” forage can be an important part of the supply to livestock.

Low utilisation rates at one time of year can, therefore, alleviate the severity of feed gaps later on. Standing pasture cannot be carried over without penalties, however, because pasture quality declines with age. Carried-over pasture is therefore especially important when pasture production is declining rapidly, but it provides some benefit for only a discrete period of time (1-8 months, depending on the environment). In systems that have strong contrasts between wet and dry periods of the year, carryover is a built-in feature of the farming system: e.g. annual pasture residues for summer grazing in Mediterranean environments or summer-grown pasture utilised in the dry season in the sub-tropics.

What this means: Allowing for carryover of pasture has a considerable effect on reducing feed gaps. Consider carryover effects at the end of the growing season, where it can have a large impact on the balance between supply and demand. But at other times of the year, it is probably more realistic to focus on fresh pasture production.

For example, the utilisation rates for a particular feed supply and demand scenario for the Avon region and another for the Murrumbidgee region are shown in Figure 6. The utilisation rates shown for those calculated using either freshly grown pasture, or using the ‘pasture carryover’ function in the MLA Feed Demand Calculator. Large feed gaps (evidenced by the peaks in the utilisation values) are evident when calculated with freshly grown pasture – especially for the Avon situation – but not so apparent when calculated using pasture carryover.

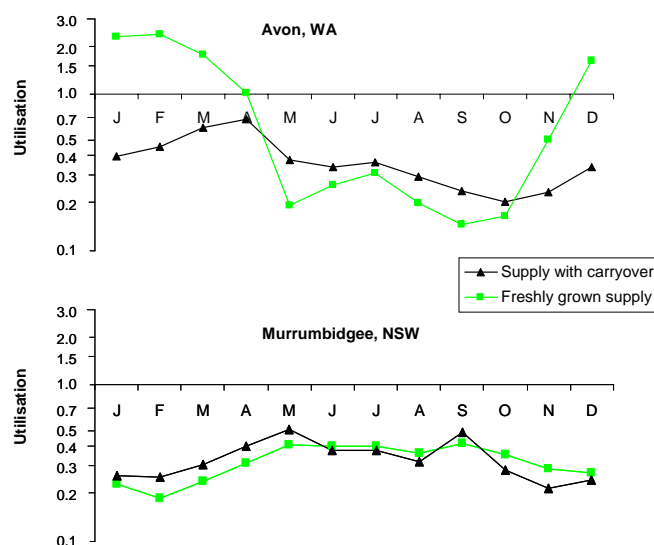


Figure 6: Feed utilisation for (a) the Avon; spring lambing, 110% lambing percentage, with 20% lucerne and 80% annual pasture, and (b) Murrumbidgee; spring lambing and calving – sheep and beef production, with access to grazing wheat in winter.

6. When considering the benefits of matching livestock demand with supply the lag effects on animal performance should be considered

As noted in point 1, the marginal value of a megajoule of pasture ME changes significantly through the course of the year. These changes reflect larger economic returns for each increment in ME supply when supply is severely limiting the animals' potential. As ME supply approaches the animals' requirements, the benefit of further increments becomes smaller. However, differences in the value of extra feed can also arise since an increase in nutrient supply can have profound effects at certain times that often extend beyond the immediate period when the nutrients are provided. Such "windows of opportunity" for improved animal nutrition include:

- Pre-joining nutrition and effects on ovulation rate
- Mid-late pregnancy nutrient on survival and future performance of the offspring (e.g. avoiding pregnancy toxemia or lifetime effects on wool growth or quality, body composition or reproductive performance)
- Early lactation nutrition and milk production, and consequent growth rates of lambs and required duration to reach market weights
- Nutrition around the time of minimum fibre diameter that will impact on wool staple strength.

It is biologically inefficient for animals to lose weight (e.g., over the period of a feed deficit) and then re-gain it later. For example, the deposition of 1 kg of protein by an animal requires about 42 MJ of energy, but it liberates only 18 MJ when broken down (oxidised) during weight loss. Similarly, 1 kg of fat deposition requires about 54 MJ of energy, but supplies only about 35 MJ of available energy when broken down. Part of this inefficiency is recouped by a lower maintenance requirement in animals that have lost weight, but simple mathematics show there is about 50% more energy required for a 'cycle' of weight gain-weight loss-weight replenishment compared with weight gain followed by maintenance. On face value, this is a considerable margin in favour of avoiding weight loss, but of course it depends on the cost of the extra feed required to prevent (or reduce) weight loss; i.e., we return to thinking about an imbalance in economic terms – see point 1.

What this means: Producers and managers should identify key periods of time when nutritional supply will have particularly profound effects on the performance of the animals. For example, in a prime lamb system, ovulation rate and postnatal growth rates may be critical to the financial position of the enterprise, whereas for a fine wool system, the impacts of nutrition on staple strength may be more important. Accordingly, extra weighting should be placed on addressing feed deficits as these critical times of the production cycle.

7. Depicting feed supply and demand curves as seasonal averages can hide a key driver of farmer behaviour: risk management during periods of larger- than-average feed deficits

Curves of average feed supply through the year will hide considerable season-to-season variation. With a given livestock enterprise this means that the size of the feed gap will be greater in some years than others. In many farming systems, farmers will be aiming to minimise the downside risk of dealing with a larger-than-average feed gap in a dry year rather than aiming to increase utilisation during a period of feed surplus. This means that they will adjust the livestock enterprise so as to minimise the occurrence of years with large feed gaps to an acceptable level. The consequence of this is that feed excesses will be a natural feature of the system in average and better-than-average seasons. Focussing on utilising this feed excess by increasing animal demand will simply increase the frequency of seasons with large unwanted feed gaps, unless there is also strategy to modify feed supply at the time of a year when a gap would be anticipated.

As a consequence of this risk avoidance strategy, an excessive feed supply (e.g., a particularly high spring flush in southern Australia) is often viewed as a lost opportunity rather than a direct cost because the pasture was growing anyway. Further, an excess in supply can contribute feed carryover for later use (albeit at a discounted quality). On the contrary, an excess in demand (e.g., less than average feed supply due to drought conditions) carries a direct cost that could be expressed in any number of ways: (i) animals will perform less than anticipated (and less than potential); (ii) animals

will require expensive feed supplementation to meet targets; (iii) animals will need to be sold (probably at low prices); or (iv) in extreme cases, animals may need to be destroyed on farm if there is no suitable market.

To illustrate how reducing a feed surplus (i.e., increasing pasture utilisation during a period of feed abundance) can have longer term undesirable consequences, we have compared a change in animal demand (the production data are directly relevant to the Avon region, but the concept has wider applicability). In this example (Fig. 7a), animal demand is increased in spring by moving from autumn to spring lambing, changing to terminal sires, increasing lambing percentage (from 85 to 110%) and increasing stocking rate. This shows an improvement in pasture utilisation in spring but exacerbation of the feed gap in autumn.

A strategy to simultaneously reduce the risk of a larger feed gap in autumn is also required to reduce the chances of an intended improvement actually causing a bigger problem at another time of year. An example of such a strategy is shown in Fig. 7b, where the pasture profile is improved by changing from annual pastures only to a mix of annual pastures, lucerne (30% of the area) and saltbush (10% of the area)..

What this means: Many farmers are likely to manage their operations to minimise risks of higher-than-average feed deficits. Therefore, when we considering modifying a farming system, we should not exclusively consider seasonal averages, but explore the full set of consequences of a change under a range of different scenarios.

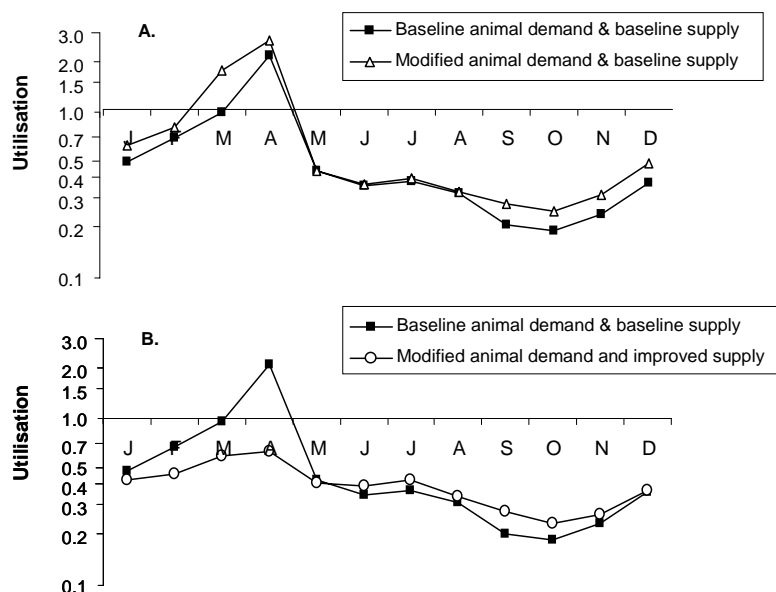


Figure 7: Monthly pasture utilisation values expressed in log form [see point 4] and using 'pasture carryover' according to the MLA Feed Demand Calculator [see point 5].

- A. The impact on monthly pasture utilisation rate (of changing animal demand to increase utilisation in spring by changing from a 'baseline' production system (autumn lambing and 85% lambing percentage) to a higher demand (spring lambing, terminal sires, 110% lambing, higher stocking rate; 'modified demand'). Pasture utilisation improves (smaller negative numbers) in spring – as expected – but a feed gap is more pronounced in autumn (high positive values).
- B. The change in monthly pasture utilisation rate by changing from the 'baseline' supply and demand to an increased demand and an 'improved' supply through the incorporation of lucerne and saltbush to provide summer and autumn feed.

8. Large variations that exist between years mean that average regional differences should not be overstated

Regional variation in average pasture supply curves

Published data on pasture growth rates for different regions of Australia have been collated and reported in our previous Milestone Report. Four of the five regions represented (Figure 8) have a peak growth rate of 50-60 kg DM/ha/day, and all of these show considerable seasonal variation. The region (central/northern NSW) that does not reach the same peak production values (<40 kg DM/ha) is also distinguished by a much smaller seasonal variation. The in broad sense, regions that show high peak values tend to also have much lower minimal values. These tend to be regions that rely on carryover of feed and supplementary feed to meet feed deficits.

Three of the five regions have a total (cumulative) production (Figure 9) of about 6,000 kg/ha (Avon, WA; NAR, WA; central/northern NSW), so despite different patterns of pasture growth during the year between NSW and WA, total production is similar. The remaining two regions (western Vic and Southern Qld) have marked different patterns of pasture growth during the year, but both reach a total production of about 10,000 kg/ha.

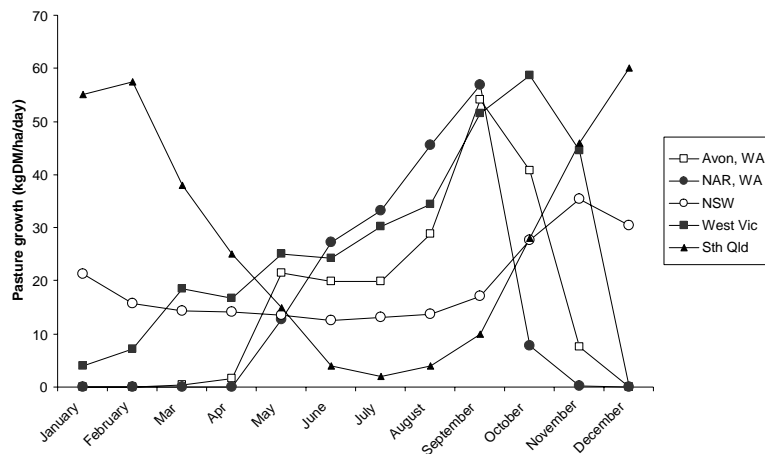


Figure 8: Pasture growth rates for five regions across Australia. Pastures in southern Queensland are based on tropical and sub-tropical species, while those elsewhere are of temperate adaptation.

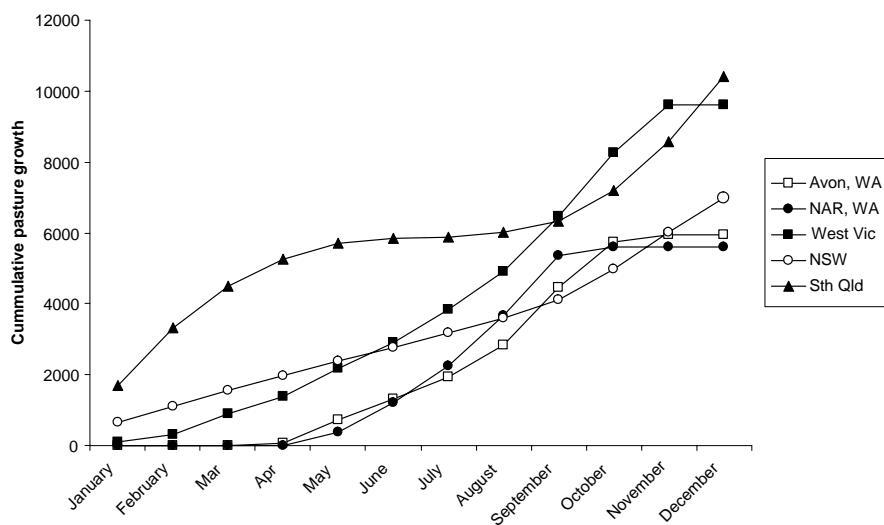


Figure 9: Cumulative pasture production for five regions across Australia.

Year-to-year variation

There is considerable variation within regions across years. For example, the year-to-year differences on an individual farm are as great as the variation between localities within a region (Figures 10 and 11) and as large as differences that can occur across regions in particular years (i.e. the pasture production profiles in some years shown in Figure 10 overlap with the some of the profiles shown in Figure 11). Pasture production on individual farms can vary two-fold in total production and the timing of the start and end of the growing season can vary by many weeks. These differences are similar in magnitude to some of the differences across sites and regions, depending on the year.

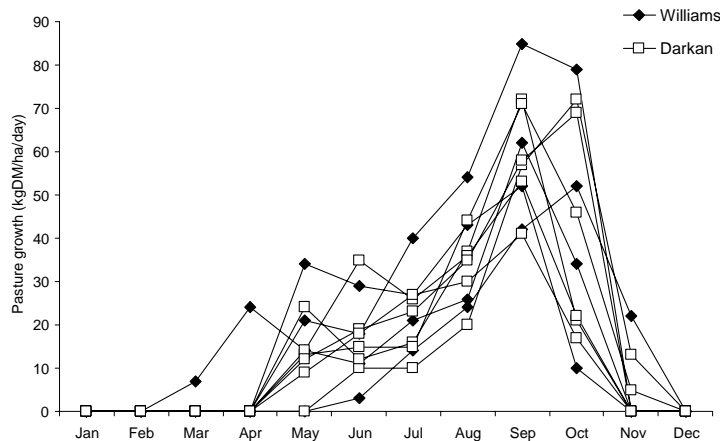


Figure 10: Examples of variation in pasture growth between sites within a region and between years within a site. The different symbols represent different localities in the Avon region; four years data are plotted for Williams and six years data for Darkan.

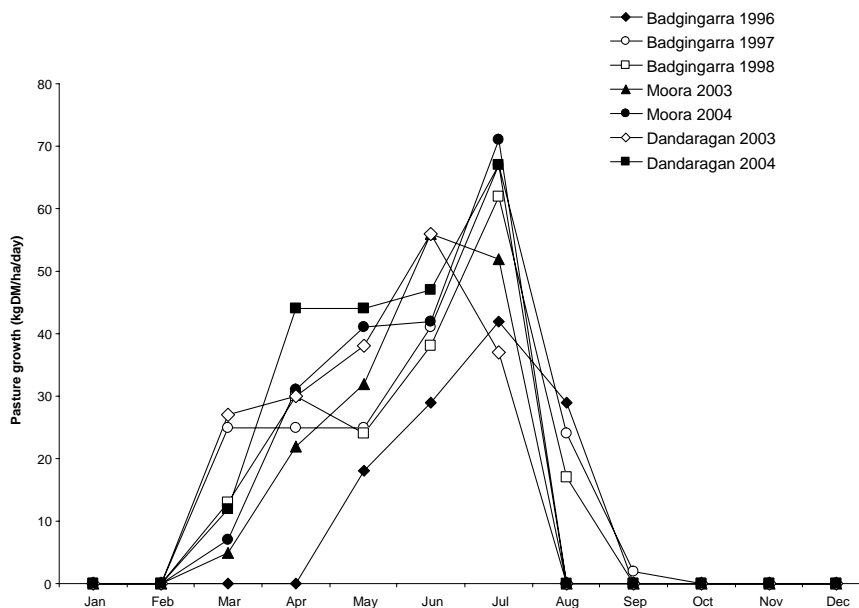


Figure 11: Examples of variation between sites and years within the Northern Agricultural Region (WA). Note the considerable overlap in growth curves in this region with those in the Avon region (Figure 10).

What this means: In designing strategies to improve feed supply profiles, there will be much in common across regions that share the same general pattern of feed supply (e.g., winter dominant rainfall, or summer active pastures etc.). Regional differences within climatic zones may influence the choice of particular pasture species (e.g., sub clover vs medic, kikuyu vs Italian ryegrass), but the main limitations and opportunities will have broad applicability.

9. Tactical versus strategic changes to feed supply: 'horses for courses'

In general, there are two main ways to alter feed supply.

1. Tactical responses as needs and opportunities arise. For example, grazing a cereal crop in winter, or using more conserved fodder out-of-season. Advantages of tactical responses are:
 - That if the need doesn't arise, there is only a small cost of not utilising the feed. For example, if wheat is not grazed in winter, then it does not go to waste as it can still yield a return as a grain crop (assuming the seasonal conditions are conducive). Similarly, if conserved fodder is not used when expected, it is still available for use later on.
 - Limited impact on the area available for pasture or cropping.Tactical responses lend themselves to incremental improvements in productivity, but may not be sufficient if more ambitious productivity targets are set.
2. Strategic responses, such as incorporating lucerne or forage shrubs into an annual pasture system. Strategic changes are likely to require more structural adjustments to the farming system but, if implemented successfully, they can allow transformational changes to the farming system (e.g., large increases in stocking rate, changing from backgrounding to finishing livestock etc.). To justify strategic responses and to make them pay, the livestock system needs to be modified to reflect – and exploit – the altered profile of feed supply.

What this means: Different circumstances will require different responses, and the different responses (tactical vs strategic) have different implications to both management and the underlying farming system.

Strategic changes that rely on opportunistic capture of rainfall to produce feed (e.g. lucerne) will be less effective than those that produce reliable feed (e.g. grazing cereals). Opportunistic systems will tend to produce feed when other sources of feed are also available (e.g. summer weeds on cropping paddocks produce feed for livestock under the same conditions that also results in lucerne production).

When a feed gap is accepted as a regular, predictable feature, of a production system – perhaps most notable in Mediterranean environments – management strategies have evolved to minimise risks in particularly poor years when the feed gap is extended and deepened. This is likely to reflect both sound economic drivers and social factors, such as avoiding the trauma of disposing of excess sheep in bad years. However, such strategies make it hard to exploit the better-than-average years because stocking rates tend to be conservative. Thus, if stocking rates should be higher to capitalise on good years and to use more of the spring surplus, for example, strategic responses must also be implemented to minimise the risk when known feed gaps exist. One example of a strategic response may be to incorporate forage shrubs on a proportion of the grazing area, allowing a higher annual average stocking rate and exploitation of the annual pastures in late winter and spring.

In environments where a feed gap is less predictable in terms of its timing and magnitude (e.g. southern Queensland and northern NSW), there is less incentive to implement a strategic response to overcome a known gap. In these situations, stocking rates are likely to be less conservative than in the above example (e.g., Mediterranean environment) and tactical responses may be more suitable to overcome more modest feed gaps.

What this means: The magnitude of known feed gaps influences the degree of conservatism in stocking rates and the type of responses (tactical vs strategic) that are more likely to be considered to reduce feed gaps.

10. The value in feed supply and demand concepts for grazing managers lies in being able to monitor the status of their system at any point in time and so being in a position to anticipate and respond to shortfalls in supply.