Filling the Feed Gap

Designing a profitable forage-based beef cattle system

A report for

NUFFIELD AUSTRALIA
FARMING SCHOLARS

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Executive Summary

The extensive use of supplementary feed to fill the seasonal feed gap in pasture-based beef systems in Southern Australia is seen as a significant inhibitor to profitability, and cost-effective alternatives to manage and fill the seasonal feed gap are explored as part of this research.

A number of recommendations are made for farmers and others involved in the beef industry. Increased collection and analysis of practical on-farm data, flexible enterprise mixes, subdivision of grazing areas, a more intensive attitude towards pasture management in the same way grain crops are managed, and two examples of annual forage sequences are proposed. This report informs readers of several practical factors which combine to create a simple and profitable beef forage system designed for Southern Australia, based on examples seen around the world.

Dual purpose winter wheat is the recommended crop to recommence the crop cycle following a period of perennial pasture and is targeted at filling the feed gap during the winter months of June and July. Following dual-purpose wheat, a short-term annual or Italian ryegrass is a suitable crop to plant, which will provide large volumes of high-quality forage from August through until early December.

Pending the results of further on-farm trial work, cocksfoot is seen to be the most suitable perennial grass species for summer production and may be used alongside chicory to deliver reliable, low risk summer grazing. Lucerne is also recommended to be included in the system, until sainfoin seed becomes commercially available in Australia. It is suggested to cut the first growth of lucerne in spring as chopped silage into a cost-effective self-feeding silage pit for use during the autumn. This option helps to capitalise on the strong production of lucerne in spring, whilst avoiding a high bloat-risk period, and coincides with a period when large volumes of forage are available on short term ryegrass paddocks which can carry large numbers of stock.

Through autumn, it is recommended that stockpiled phalaris pasture is utilised to feed non-lactating pregnant animals, whilst an opportunity exists to utilise a self-feeding silage pit (lucerne silage) to feed young stock.

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Foreword

The Tait family business is based across three farms, totalling 2,000 hectares (ha) on the New South Wales central tablelands. At Mandurama, we run approx. 550 Angus breeding cows, and finish all progeny aside from replacements, and also finish between 300 and 1,000 trade steers annually, from a grass-based system. We aim to turn off steers to Certified grassfed programs at +550kgs liveweight, and second draft cattle are sold to feedlots between 450 and 520kgs liveweight. We also grow wheat and canola in a 100% cropping program at Canowindra and are expanding our dual-purpose cropping program at Mandurama.

Since my father handed over the day-to-day management of the business, I have become particularly enthusiastic about continuing to develop a profitable farming system and boosting the productivity levels of our farms, which in general I believe are under-utilised. The climate and rainfall the region receives is not being used as effectively as it could be to produce food. No one is making any more farmland, so we must make the most of the land we have. I believe this is true for many areas of southern Australia, especially where livestock are the predominant farming enterprise. I have played a major role in establishing an informal farm discussion group amongst younger farmers in the Mandurama district to enable members of the group to share knowledge and learn from each other, as well as a number of visiting guest speakers.

Acknowledgements

I am very fortunate to have been able to take 18 weeks away from a family business, and in particular thanks go to my dad John for "stepping up to the plate", and also to our agronomist Peter Wilson for all his guidance and assistance.

A big thank you must go to Nuffield Australia and Meat & Livestock Australia for making this once in a lifetime opportunity possible. Without your support I would never have had the privilege of travelling the world studying and learning about agriculture. It has opened many doors that otherwise would not have been opened and is the gift which keeps on giving.

Thank you also to my parents John and Jo and fiancé Izzy for supporting me on this journey. I definitely would not have been able to do it without you.

Thank you to all the wonderful people who I was fortunate enough to meet during my time travelling through the USA, Canada, Ireland, Scotland, Wales, England, Uruguay, Argentina, and New Zealand. You were all very generous with your time, your hospitality and sharing your knowledge.

I wish to express a sincere appreciation to all the people and organisations listed below. Their assistance, generosity, hospitality and knowledge are truly valued. Whilst not all are personally mentioned in the body of the report, may they rest assured that every individual made a significant contribution to the scholarship experience. Thank you.

<u>United States of America</u>

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<u>Canada</u>

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Ireland

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United Kingdom

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Argentina

The team at the International Herbage Seeds Conference, held in Pergamino, October 2017.

New Zealand

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Abbreviations

BMR – Brown Mid Rib

C/KG – Cents per Kilogram

CSIRO – Commonwealth Science & Industrial Research Organisation

DM – Dry Matter

EBIT – Earnings Before Interest & Tax

GM – Genetically Modified

GPS – Global Positioning System

GRDC – Grains Research & Development Corporation

Ha – Hectares

LLS – Local Land Services

LWT – Liveweight

N – Nitrogen

NSW – New South Wales

SPACE – Satellite Pasture and Cover Evaluation

SWFMP – South West Farm Monitor Project

UAV – Unmanned Aerial Vehicle

UFL – Unite Fourragere Laite

UK – United Kingdom

USA – United States of America

Objectives

The initial aim of this Nuffield Scholarship was to investigate integrated beef and cropping systems, with a focus on dual purpose cropping systems. These feature an annual crop, typically winter wheat, usually planted in autumn, grazed by livestock in winter then managed through to grain harvest the following spring. Emphasis was placed on systems involving beef animals as opposed to sheep. It was suggested that significant research has been conducted on sheep grazing systems in Australia. However, there are some significant differences and knowledge gaps which required investigation for beef cattle systems. The focus of study then shifted to look at the overall beef forage system, including the role that dual-purpose crops play in the system.

This broad approach led to the development of the following objectives:

- To investigate profitable means of filling the seasonal feed gap and eliminating the need for supplementary feeding in forage-based beef finishing systems.
- To study intensive forage-based beef finishing systems across a range of different production zones whilst still maintaining a focus on similar climatic conditions to those experienced in Southern Australia.
- To investigate the role and management considerations for dual purpose cropping in forage-based beef systems and in filling the seasonal feed gap.
- To investigate new and existing species and varieties of pastures, fodder and grain crops which may be suited to beef production in Southern Australia.
- To study the overall profitability and productivity of integrated beef and cropping systems, including simple ways to measure, compare and manage enterprise and business performance.
- To develop an understanding of methods used to accurately measure and manage pasture and fodder. This encompasses grazing management, dry matter measurement, pasture budgeting and seasonal planning, benchmarking, and enterprise analysis, with a focus on maintaining a high labour efficiency whilst intensifying the system.
- To design a profitable, resilient and simple year-round forage based grazing system suited to beef cattle production.

Chapter 1: What is a Forage-Based Beef System?

This report discusses designing a forage-based system and some ways to manipulate and manage both the animals and the forage to create a profitable business.

For the purposes of this report, a forage-based beef system can best be described as a farming system which relies on the grazing of a range of pasture and forage species on a year-round basis with beef cattle in an outdoor, unconfined environment. The forage-based system is unlike a feedlot system where animals are confined to smaller pens and fed on a grain-based ration. The two key components of the system, being the animals and the forage, can be individually manipulated and managed to create a profitable system.

1.1 The feed curve and the feed gap

In an Australian climate, which can be described as highly variable, changes in weather have a significant effect on pasture growth and availability. A 'regular' seasonal pattern can be represented as the annual feed curve, or pasture growth curve. An example of a typical pasture growth curve for Southern Australia is shown in Figure 1 below.

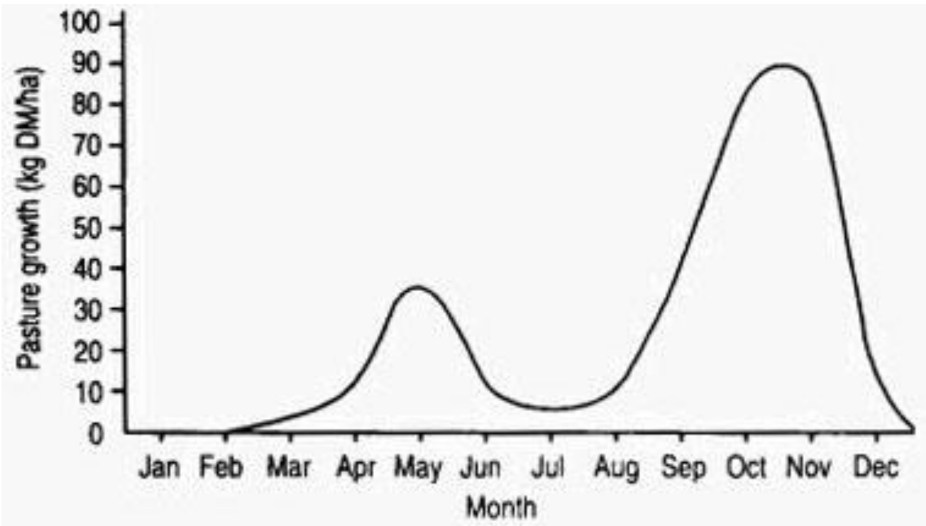


Figure 1: Typical pasture growth curve (Vic Agriculture 2018)

Traditionally, many farmers have turned to expensive sources of supplementary feed to fill feed gap periods where animal demand exceeds pasture supply. This supplementary feed may be bought in from other producers or may be conserved on farm from periods of excess pasture availability, usually in spring, and may be in the form of hay, straw, chopped or baled silage, grain or a manufactured product such as pellets.

There are a number of problems with the traditional way of filling the feed gap by using supplementary feed, the main one being the high cost of supplementary feed, as shown in Figure 2 below. Please note, UFL is the unit used in Irish farming systems to compare the value of feeds and is defined as the energy contained in one kilogram of standard air-dried barley.

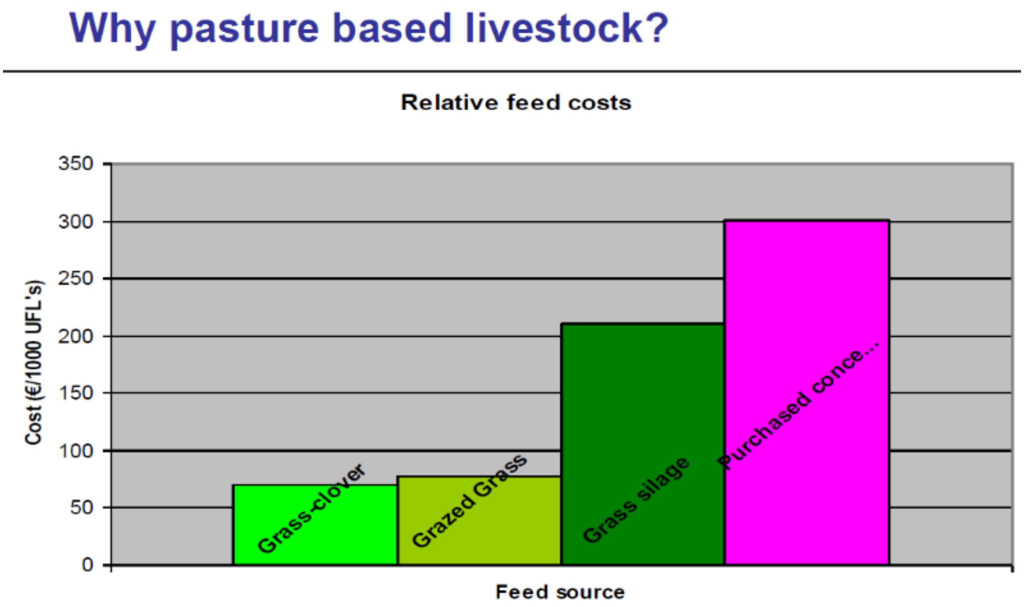


Figure 2: Costs of different feed sources (Teagsc, 2017)

To quote author Jim Gerrish in his book 'Kick the Hay Habit', "the cost of hay has grown to exceed its value" (Gerrish 2013). The best way to describe the high cost of making (or purchasing) supplementary feed is through the following example. A farmer is growing ryegrass pastures on farm, which are ready to graze today. The farmer can either decide to take an animal to graze the paddock as it stands today, or they can turn that grass into supplementary feed to use during the seasonal feed gap. One kilogram of the farmers ryegrass (dry matter) has cost approximately eight cents to grow, including seed, fertiliser, machinery costs, labour and herbicides. If they graze it today, there is no additional cost. If they decide to make that kilogram of ryegrass into supplementary feed, it is likely to cost an additional 15 to 30 cents (depending on a few factors, such as if it is being made into hay or silage, and if using their own machinery or a contractor). The farmer then has to store that feed and then at a later date there is a cost associated with feeding that hay/silage out to their animals. Remember that it is still only one kilogram of ryegrass, but it has now cost well over 20 cents, compared to eight cents when it was standing in the paddock. The high cost of supplementary feed in Australian livestock systems and its impact on profitability is confirmed by an analysis of the data from the 2016/17 Victorian South West Farm Monitor Project (SWFMP), which collects data from a range of farms across the State of Victoria and ranks farms according to Return on Asset, and Earnings before Interest and Tax (EBIT) per hectare, and gross margin per hectare per 100mm rainfall. When variable costs are analysed for beef farms, the farms ranked in the top 20% (gross margin per hectare per 100mm rainfall) are spending $27/ha on supplementary feed and agistment, whilst the average of farms in the survey are spending $68/ha (SWFMP 2017).

The key problem for most dryland producers in Southern Australia, is that they are unable to grow ryegrass for 12 months of the year, as shown by the annual pasture growth curve. This report is aimed at solving this problem, by investigating a number of ways to provide cost-effective, high quality forage for beef animals year-round.

Chapter 2: The Jigsaw Puzzle

A forage-based beef system can be likened to a jigsaw puzzle. Before examining some of the pieces of the puzzle, it is important to understand what the final picture will look like. As mentioned, one aim of this report is to design a simple system, and many of the strategies and practices discussed are exactly that - simple. The key is to be able to put all the individual pieces together to create the big picture, which is where this report is targeted.

2.1 From the ground up; treating pastures like crops

Before delving into the particulars of a forage-based beef system, any fundamental deficiencies in the soil must be corrected, be they related to physical, biological or chemical properties. Soil health is an entire topic on its own which is not explored in depth in this report, other than to say it is vital to have fully functioning healthy soil for a sustainable forage-based beef system. The role of a fully functioning soil in a mixed-species pasture situation is discussed below.

Generally, the broadacre cropping sector in Australia is further advanced than the beef sector when it comes to fine tuning inputs and understanding in detail the cost-benefit analysis of variable inputs. Most cropping farmers will have a solid understanding of their individual input costs per hectare and their returns per hectare, and how these two figures interact to affect profitability. Aside from the obvious and all-important climatic factors, growing a high yielding crop can often be achieved by following a set and repeatable recipe involving the correct nutrients, chemicals and matching timing of operations with variety choice. This is adapted to current and expected climate conditions and is well-recognised by farmers and agronomists. This is not generally the case in the beef industry, where per head costs and returns are more often quoted rather than per hectare, if at all. Developing a repeatable blueprint for successful beef production is discussed further in this report. A strongpoint of many New Zealand livestock systems was the level of intense management where pastures and forages are finely tuned based on a known recipe, individual input costs are well known, and essentially the pastures are treated in the same way as a grain crop.

2.2 Trading vs capital stock; the impact of enterprise mix on flexibility

The enterprise mix will vary greatly depending on an individual's preference for breeding stock versus trading stock. The topography and land class will also affect the enterprise mix on a property, with breeding stock well suited to less productive and non-arable land. A key consideration when deciding on the enterprise mix between trade stock and breeding stock is how the mix will affect the flexibility of the business to adapt to varying seasonal conditions. A business running 100% breeding stock and producing a store animal for sale has a limited ability to cope with both ends of seasonal variation. Trade stock offer a higher level of flexibility for a business, as stocking rates can be adjusted at short notice, based on seasonal conditions, with minimal reliance on supplementary feed.

The takeaway message here is to be aware of the effect that enterprise mix can have on the ability of a pasture-based system to deal with fluctuations in seasonal conditions without having to rely on expensive supplementary feed. Many businesses around the world will focus on two or three enterprises, usually including a breeding unit and a separate finishing or trading unit. This allows a great deal of flexibility, while remaining a simple system to manage.

Chapter 3: Information is Power

A high degree of technical understanding and accurate pasture measurement was a common theme amongst producers around the world with successfully established forage-based beef systems.

Lochinver Station, on the North Island of New Zealand is one example, where pasture mass and growth rate is measured and recorded monthly across all 9,500 hectares. This information is entered into the Farmax software program and compared with average figures for the farm for the corresponding paddocks and time of year. The manager is then able to use this data to work up to six months in advance with grazing decisions. If the pasture figures are below average, there will be less grass available at some point in the following six months. This may mean that some animals are sold earlier, or trading stock are not purchased. If there is above average pasture cover available, trading stock may be purchased, or paddocks may be cut for supplementary feed which is sold to other farms. By having this information available, the manager can make key decisions on time, rather than guesswork. There are several pasture management and budgeting software products which provide farmers with the platform to record and analyse pasture information; Farmax (Farmax 2018) and Farm IQ (Farm IQ 2018) are both popular in New Zealand, and Maia Grazing (Maia Grazing 2018) is a new program which has been developed in Australia. Many producers visited still use Microsoft Excel which is low cost and can offer a great deal of customisation and simplicity for a knowledgeable user.

The first step in this process is to start collecting information on a regular basis about pasture mass and growth. In 'Kick the Hay Habit', author Jim Gerrish (2013) provides a detailed summary on conducting a pasture inventory, including discussing three different methods of measurement. Meat & Livestock Australia's More beef from pastures program webpage (More Beef 2018) also has some useful information relating to pasture measurement.

For many Australian producers it may seem time-consuming and costly to measure pasture covers in each paddock on a monthly basis. There are a number of companies currently developing technology which will ultimately measure available pasture, daily pasture growth, and pasture quality automatically. The Noble Research Institute in Ardmore, Oklahoma, is one such organisation which is in the process of developing sensor technology which can be mounted on a UAV (Unmanned Aerial Vehicle, or Drone), which can then be programmed to fly a regular route over a paddock or farm and automatically record data. Twain Butler from the Noble Institute is pictured in Figure 3 below with a prototype ground-based vehicle testing some of the newly developed pasture sensors.

Figure 3: Twain Butler with a prototype pasture sensor at the Noble Research Institute, Ardmore, Oklahoma (Source: Author)

Another tool being developed in Australia is the web-based "Pastures from Space" (Pastures from Space 2018), which uses satellites to provide data on a local government district pasture growth, or for an annual subscription Pastures from Space Plus can provide pasture data for a farm down to the individual paddock level. Figure 4 below is an example of the data provided for Blayney local Government area (NSW), and Figure 5 shows the customized subscription service. This information is readily accessible and is an excellent place to start when establishing an annual pasture growth curve for a farm. The quality of information provided by current technology is improving each year; currently the information from satellites can be unreliable or inaccurate. However, as the sensor technology improves, the quality and reliability of information will also improve, allowing farmers to be more confident in making accurate decisions.

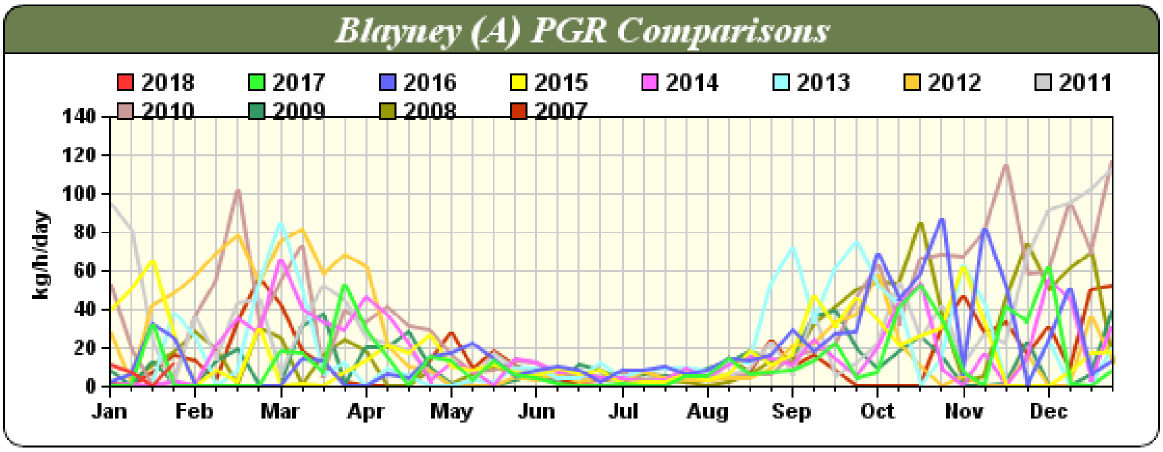


Figure 4: Pastures from Space dataset

New Zealand company LIC has released a similar product to Pastures from Space, called SPACE (Satellite Pasture and Cover Evaluation), which provides daily pasture data reports and includes images of the farm, a feed wedge chart, and paddock ranking based on available dry matter (SPACE 2018).

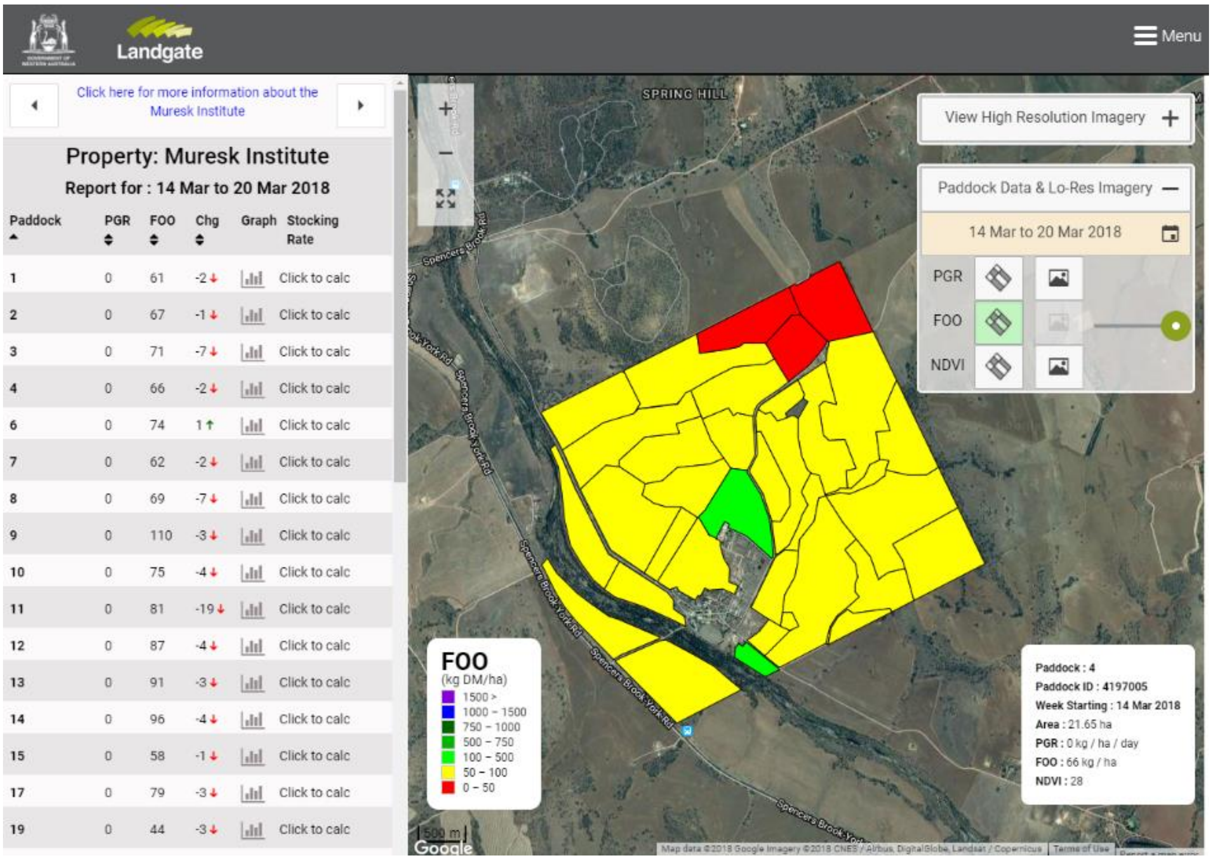


Figure 5: Pastures from Space Plus sample farm output (Pastures from Space 2018)

3.1 The importance of planning and timing

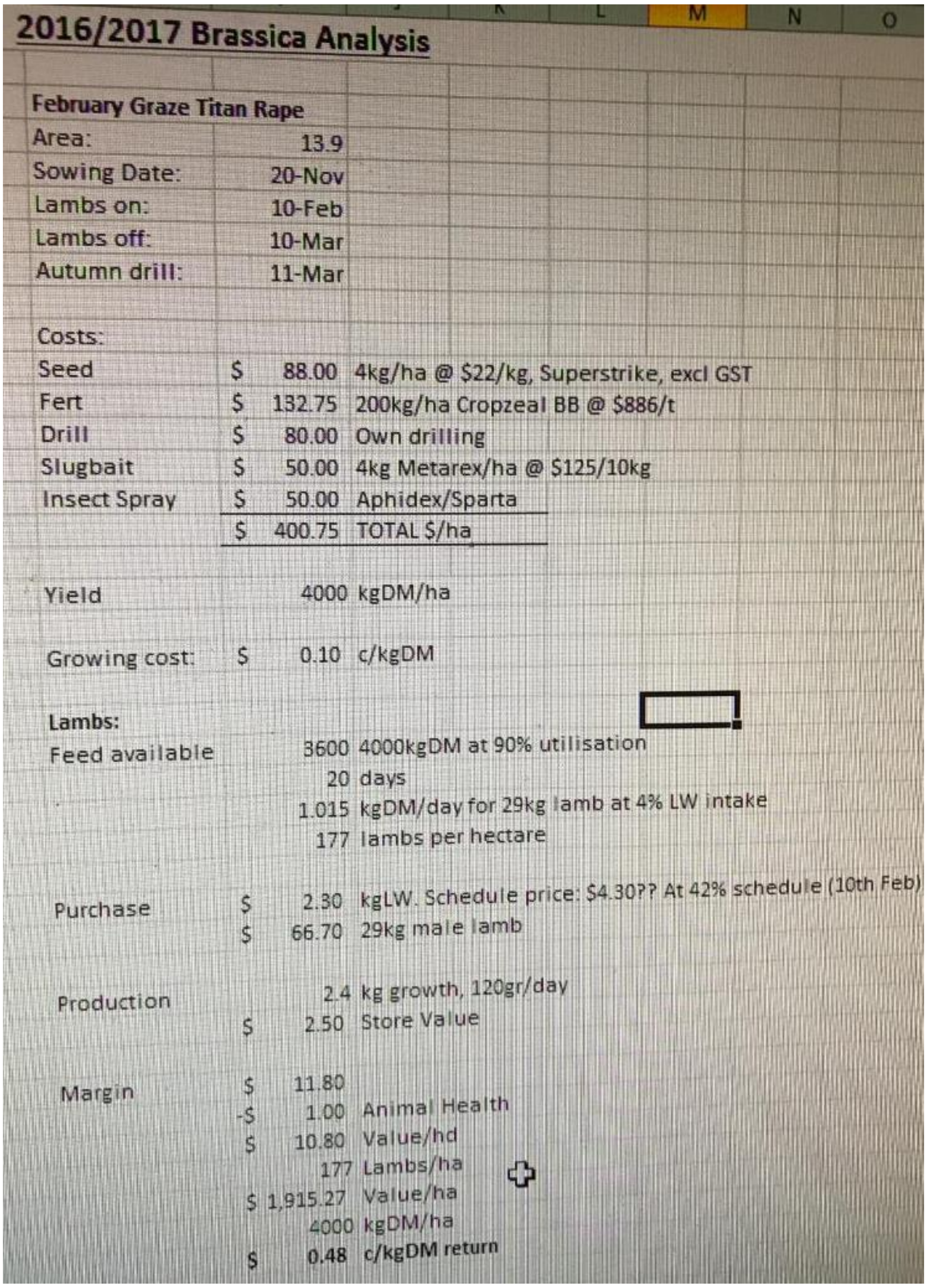
Another common theme amongst farms visited was the importance placed by management on getting timing of operations right. A great deal of planning went into each operation which ensured that tasks were done on time and resulted in the best outcome. Many have key trigger dates set on the calendar for certain operations to be carried out.

In the case of John and Catherine Ford from Highlands Station near Rotorua, New Zealand, planning is taken very seriously. The Fords have drawn up a full calendar of operations detailing each and every task on the farm which needs to be undertaken, when is the ideal time to do it and any instructions. It is essentially an operator's manual for their business and is specifically designed so that an outsider with no pre-existing knowledge of the Ford's farm could come in and follow the calendar of operations and the business would continue to run as normal. This high level of organisation also allowed the Ford's to increase their labour efficiency during peak times.

Timing of changes to stocking rate can be especially important in a forage-based system. In a breeding enterprise, calving should be coordinated with the peak of the feed curve, as this is when lactating cows are in peak energy demand. For a trading enterprise, animals should ideally be purchased when there is a foreseeable period ahead with good availability of quality forage, and management should aim to have animals fattened and sold prior to the seasonal feed gap. Getting these basics wrong is often when expensive supplementary feeding is called upon to remedy the situation. Jim Gerrish discusses getting the timing right between peak stocking rate and peak feed availability in Chapter 7 of 'Kick the Hay Habit' (Gerrish 2013).

3.2 Making every cent count

The top performing enterprises in New Zealand are matching pasture growth and costs with livestock demands and performance, enabling them to measure which enterprise is giving the best financial return on a kilogram of dry matter. An example of this was seen at Foley Farms in Hawkes Bay, where an intensive grazing livestock finishing system is established utilising a number of short-term pastures and forage crops. The cost of each individual crop is known, along with the total production of dry matter for a given period of time. This is then translated into livestock performance using standardised assumptions of forage utilisation percentages, and daily weight gains (Figure 6).



2016/2017 Brassica Analysis

February Graze Titan Rape			
Area:		13.9	
Sowing Date:		20-Nov	
Lambs on:		10-Feb	
Lambs off:		10-Mar	
Autumn drill:		11-Mar	
Costs:			
Seed	$	88.00	4kg/ha @ $22/kg, Superstrike, excl GST
Fert	$	132.75	200kg/ha Cropzeal BB @ $886/t
Drill	$	80.00	Own drilling
Slugbait	$	50.00	4kg Metarex/ha @ $125/10kg
Insect Spray	$	50.00	Aphidex/Sparta
	$	400.75	TOTAL $/ha
Yield		4000	kgDM/ha
Growing cost:	$	0.10	c/kgDM
Lambs:			
Feed available		3600	4000kgDM at 90% utilisation
		20	days
		1.015	kgDM/day for 29kg lamb at 4% LW intake
		177	lambs per hectare
Purchase	$	2.30	kgLW. Schedule price: $4.30?? At 42% schedule (10th Feb)
	$	66.70	29kg male lamb
Production		2.4	kg growth, 120gr/day
	$	2.50	Store Value
Margin	$	11.80	
	-$	1.00	Animal Health
	$	10.80	Value/hd
		177	Lambs/ha
	$	1,915.27	Value/ha
		4000	kgDM/ha
	$	0.48	c/kgDM return

Figure 6 Example spreadsheet calculating financial return per kilogram of dry matter produced from a forage brassica crop in New Zealand (Abbiss 2018)

Chapter 4: Pieces of the Puzzle

To examine some of the individual pieces of the puzzle which together make up the system, a season-by-season approach has been taken in this report, which will allow the feed curve to be broken down and solutions to filling the feed gap can be put forward. A limited selection of pasture and forage crop species of particular interest will be examined, along with grazing strategies.

It is noteworthy that, after visiting many farmers and pasture industry experts around the world, everyone has their favourite plant species. This concept of a favoured species was taken a step further by the Avery family, who farm in one of the driest parts of New Zealand in the Marlborough region at the top of the South Island. When discussing the whole farm system, Fraser Avery said it is important to find a plant species which can form the backbone of the system. This plant needs to be well suited to the environment and production system, and should be a low-risk, reliable plant which will perform across a wide range of seasonal conditions. From this point the range of plant species included in the system can then expand to include more specialist forage crops, which can be used to fill smaller gaps in the feed curve and complete the cycle. In the case of the Avery family, lucerne (alfalfa) was the key species which formed the centrepiece of their farming system. The opportunity to use lucerne in a forage system is discussed later in this report.

4.1 Grazing management and subdivision

The one theme which was common across all visits and discussions around the world was paddock subdivision and paddock size or mob grazing allowance. Whilst the grazing system and paddock sizes varied between countries and farms, all farms were working towards (or already had achieved) smaller paddocks and more tightly controlled grazing. Some reasons for this strategy include:

- **Higher utilisation**- by reducing paddock sizes and reducing the number of days a mob of animals are in the one grazing area, the percentage of total dry matter in the paddock utilised by the animals increased. In other words, smaller paddocks resulted in less feed being wasted from soiling and trampling. One factor involved in this is access to stock water; a visit to Lochinver Station near Lake Taupo in New Zealand was a large-scale example of a paddock subdivision project in action across 9,500ha. Across the property, paddocks were being strategically subdivided into 10ha with permanent fencing, stock water points being located on a grid layout in the paddocks to allow further subdivision with temporary electric fencing. Formerly, the 20ha and larger paddocks would have a sole water point located in the corner of a paddock, which resulted in heavier grazing pressure close to the water point.

- **Rationing**- Subdivision particularly benefits breeding animals and is less important for finishing young stock. At certain times of the breeding cycle, specifically post-weaning, where non-lactating pregnant cows can often be placed on a maintenance diet, the ability to ration forage is valuable. By reducing paddock sizes, animal intakes can be restricted.
- **Quality control**- Smaller paddocks allow a more even grazing of paddocks to occur, and better control over the growth stage of plants. Grazing pastures can delay the onset of flowering and seed set and the associated decline in forage quality. In situations where pasture growth exceeds animal demand, paddocks can be locked up and stockpiled, whilst grazing pressure is concentrated on other paddocks to maintain quality forage to allow timely finishing of stock.

4.1.1. Rotation, rotation, rotation!

A comprehensive lesson in rotational grazing management occurred during visits to a number of grass-based beef and dairy producers, including fellow Nuffield and India Global Focus Tour Scholars Ed Payne in Roscommon, Ireland, and David Hichens in Cornwall, England, along with Nuffield scholars John Alvis (England), Gareth Davies (Wales), and Robert Fleming (Scotland). A phrase often heard when visiting farms was “grass grows grass”. The lesson here is that decisions on when to shift a mob of grazing animals should be based on a pre-determined grazing residual. Shifting a mob on time, when the residual is at an acceptable level will leave a bigger ‘solar engine’, or leaf area, remaining in the paddock, which will drive faster plant regrowth. Conversely, lax grazing and letting pasture grow beyond canopy closure results in greater wastage of grass, as the lower leaves on the plant begin to senesce and die. Overall annual dry matter production, and pasture persistence can be improved by monitoring grass growth and regrowth times and adjusting grazing rotations accordingly to prevent overgrazing or the grazing of immature regrowing leaves. According to Gareth Davies, a good guide to a target grazing residual is 'golf ball height'. Grazing below golf ball height will have a detrimental effect on regrowth. The effect of post grazing residuals on pasture growth rates in tall fescue and smooth bromegrass is demonstrated in Figure 7 below.

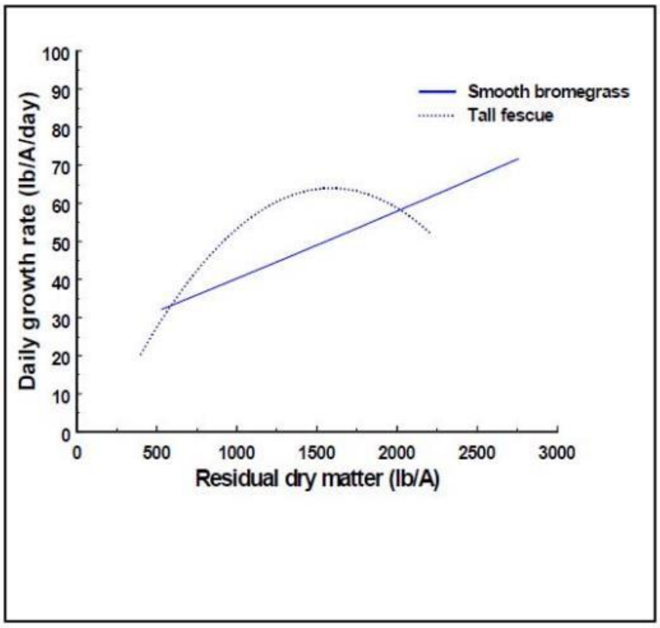


Figure 7: Effect of post grazing residual on pasture growth rate (Gerrish 2003)

All dairy producers visited, along with a number of beef finishers, spoke about the current length of their rotation. It is noteworthy that set stocking was rarely seen on farms, with rotational grazing by far the preferred practice. The rotation length refers to how many days it takes for a mob of animals to graze each paddock in the grazing cell and return to the first paddock grazed. The speed of the mob rotation is determined by how fast the grass is regrowing after grazing. In winter, with low soil temperatures, regrowth is slow. This means animals can remain in one paddock for a longer period of time without grazing regrowth and potentially having a negative effect. In spring, when pasture growth rates are high, animals need to be shifted more frequently to avoid grazing regrowth. When pasture growth outstrips grazing demand, paddocks are skipped in the rotation and stockpiled (or cut for silage). Stockpiling pasture is discussed below.

The frequent shifting of animals is very well suited to a dairy enterprise, where the animals are moving to and from the milking parlour on a daily basis regardless. In a beef system, such a daily rotation does not come without some downsides; labour efficiency is a major consideration if several mobs of animals are shifted on a daily basis. Secondly, there is an increased infrastructure requirement in such an intensive system. A reticulated watering system is almost certainly required, as is an electric fence network involving temporary fences.

The question was asked as to whether the increased production generated from rotational grazing was sufficient to pay for the expense of the additional infrastructure required. Robert Fleming (2015 Scholar) stated that the costs of switching from a set stocking system to a more intensive rotational grazing system were “negligible” when compared to the increased production. Some the numbers from the Fleming’s’ system are staggering; stocking rate on their farms increased from 5.5hd/ha to 10hd/ha, pasture utilisation increased from 50% to over 80%, whilst nitrogen fertiliser inputs remained stable and overall dry matter production increased by 50%. This change also reduced the period that animals were housed for during winter and eliminated the need for feeding concentrated feedstuffs.

4.1.2. Per head vs per hectare analysis

A change in the way beef enterprise performance is traditionally analysed needs to occur, with a shift away from focusing on per head performance towards per hectare performance. In a rotational grazing system, daily liveweight gains per head were often reported to be less than those in set stocking systems, however the stocking rate is higher in the rotational grazing system, hence the total daily liveweight (lwt) gained on a per hectare basis is greater, leading to increased profits. Robert Fleming found an increase in average annual liveweight produced per hectare from 500kg lwt/ha across the whole farm to 730kg lwt/ha with rotational grazing, and is striving towards an impressive target of 3,000kg lwt/ha annually, which he has already achieved in one grazing cell with zero supplementary feed.

4.1.3 Labour efficiency

There appears to be a fine line with the ultra-intensive rotational systems such as the techno grazing systems which are found in New Zealand. Some systems were experimenting with shifting several mobs of animals several times each day; however, in many cases, the additional labour cost of this level of intensity was greater than the value of additional performance gained. To many people, shifting multiple mobs of animals every one or two days can become laborious, and can become a logistical problem during busy times on the farm such as harvest or planting when labour resources are already stretched. Whilst there are undoubtedly benefits of more frequent movement of stock, a balance, or “sweet spot” must be found to suit each individual operation.

Virtual fencing is a major technological development which has the potential to revolutionise the grazing industry worldwide, and it is now on the verge of reaching commercial release in Australia in late 2018 with a partnership between the CSIRO and Victoria-based Ag tech company Agersens. The system currently involves animals wearing a GPS enabled electronic collar, which links to farmer operated computer software. The animals are trained to respond to a series of audio cues and electric shocks to remain within the designated grazing area.

The commercialisation of virtual fencing technology has the potential to massively increase the labour efficiency of beef operations, by allowing one operator to allocate new areas of forage to several separate mobs of stock on a daily basis (or as otherwise desired) all from the touch of a screen. This in turn is likely to encourage producers to further intensify their rotational grazing systems and increase productivity.

4.1.4. Transitioning

Transitioning animals from one feed source to another is an often-overlooked component of a beef finishing system. A well-managed transition will ensure animals continue to gain weight throughout the process. A normal transition period will range from 4-5 days through to more than 14 days. Some considerations when transitioning animals include assessing the type of feed sources involved; if animals are shifting from one species of grass to another then little to no transition is required, compared to shifting from dry stockpiled feed to a dual-purpose crop, or from a grass pasture to lucerne. In the example set by the Avery’s in New Zealand, transitioning stock from grass-based forage in spring on to lucerne over summer is a critical period and specific mixed species pastures containing both grass and lucerne are used for this purpose. In some instances, animals will be moved onto the new forage for a few hours each day to graze before being removed again until the rumen adjusts to the new feed. When planting a specific forage crop such as a brassica Robert Fleming (2015 Scholar) would plan to leave a wedge-shaped area of the paddock remaining as grass (not planted to brassica). He would then use temporary electric fencing to allow the animals to initially graze a strip of the paddock containing mainly grass with a small proportion of brassica. As the week progresses the electric fence is moved further down the paddock and the wedge of grass gets narrower, providing the animals with a larger percentage of brassica and less grass until they are eventually on a diet of pure brassica.

When planning the system across a farm or grazing cell, consideration must be given to the number of different forage types in the system at any given time. Once animals are successfully transitioned onto a forage type, it is preferable to keep them grazing on that forage type for as long as possible, as opposed to only having one small paddock to graze before returning to another type of forage. Frequent shifting from one forage type to another can result in poor animal performance due to the rumen constantly adjusting.

4.2. The mixed species discussion

Differences between species in a sward can create a dilemma for managers when managing the grazing of a mixed species pasture. The benefits of a diverse pasture over a monoculture are often articulated by experts worldwide and are best summarised in an article written by John King (King, 2018) which outlines improved animal performance, increased dry matter production and a longer growing season from more diverse pasture mixes compared to monocultures. However, consideration must be given to the effective grazing management of the diverse sward to ensure the persistence of the desired species. A monoculture system is easier, cheaper and simpler to manage, yet this can come at the cost of reduced productivity per hectare, along with fewer purported long-term benefits to soil health.

The debate between mixed or pure swards is also occurring throughout the dairy industry, particularly in the United Kingdom and Ireland. Most traditional grass-based spring calving dairy systems rely on a pure perennial ryegrass pasture, with synthetic nitrogen fertiliser supplied to drive production. When questioned on the reasoning for growing pure sward ryegrass, farmers stated that pure sward ryegrass is cheap, grows well, responds well to nitrogen application, is well suited to the climate, simple and highly effective, easy to manage and has proven to be resilient through a range of seasonal conditions. There is also little knowledge of alternatives or potential mixed sward options. Pressure is being applied by regulatory bodies to limit application of nitrogen fertilisers to farm land, and this is now driving exploration of some mixed-species pastures with greater legume content. A multitude of experts are conducting research into multi-species pastures, including the SmartGrass project being Coordinated by University College Dublin, Ireland (SmartGrass, 2017).

It was pointed out by Edward O'Riordan at Teagasc in Ireland that within Irish agriculture, beef as an enterprise is "inherently less profitable than dairy". This inherent low profit margin in beef has also been seen in Australia over many decades (until recent years) and may have led to a common attitude amongst traditional beef producers that investment in soil amelioration and high rates of fertiliser are unjustifiable. A recent pasture legume survey conducted by Dr Belinda Hackney (NSW LLS 2015) has shown this attitude to be false. This survey found that across 225 paddocks throughout central New South Wales over 90% of pastures suffered from poor nodulation in legumes. When performing in a healthy system, these legumes drive pasture production and livestock performance. The key factors which were reported to be restricting legume nodulation were soil pH, fertility and in some cases chemical residues. The key message here is that adequate soil fertility is essential to provide a good environment for legumes to function and the pasture system will then maintain itself; high soil fertility does not occur naturally in most Australian soils and beef producers need to invest in soil amelioration and fertility improvements. This point is confirmed after analysing the data from the 2016/17 Victorian South West Farm Monitor Project. When variable costs are analysed, the farms ranked in the top 20%, based on return on assets, are spending $12/ha on pasture seed and $68/ha on fertiliser and soil conditioners, compared to $10/ha and $52/ha respectively for the average farms in the survey (SWFMP 2017).

4.3. Pastures for summer grazing

There are a range of pasture and forage options which have shown promising performance for grazing over summer.

- **Continental cocksfoot**; Allister Moorehead from Agricom is part of a team in New Zealand who are conducting trials comparing Savvy Cocksfoot with Halo perennial ryegrass in a long-term paddock scale trial under standard management conditions. Data is being collected on a number of criteria, including financial return per kilogram of dry matter produced, and kilograms of beef produced per hectare. Under extremely high fertility (in excess of 450 units N per hectare) the cocksfoot was outperforming the perennial ryegrass in all benchmarks. Under 'normal' management practices with moderate fertility and 150 units N per hectare, the perennial ryegrass produced slightly more dry matter and kilograms of beef, however this is likely to be offset by cocksfoots extended persistence over perennial ryegrass. This trial has shown that new cocksfoot varieties are certainly capable of filling a role in an intensive grazing system. The persistence of cocksfoot is a major attribute of the species, as it is able to withstand extended periods of heavy grazing and dry conditions, such as those experienced in Southern Australia.

- **Continental tall fescue**; as a general comment (not specific to individual varieties) tall fescue is earlier maturing than cocksfoot, which means two things for the grazing system. Tall fescue will produce more of its dry matter earlier in spring when compared to cocksfoot, but due to its earlier maturity, its quality declines earlier in summer and produces less forage over summer than cocksfoot unless in a dominant summer rainfall zone. For many beef producers in Uruguay both continental and Mediterranean type tall fescue varieties form the backbone of the system. According to PGG Wrightsons Uruguay agronomist David Rochon, over a five year period pastures featuring tall fescue will produce dry matter at a cost of 5-6 c/kg DM, compared to annual ryegrass (reseeded each year) at a cost of 9-10c/kg DM. Figures 8 and 9 below are examples of research work conducted by pasture seed company Agricom comparing annual and seasonal performance of ryegrass, continental tall fescue and cocksfoot.

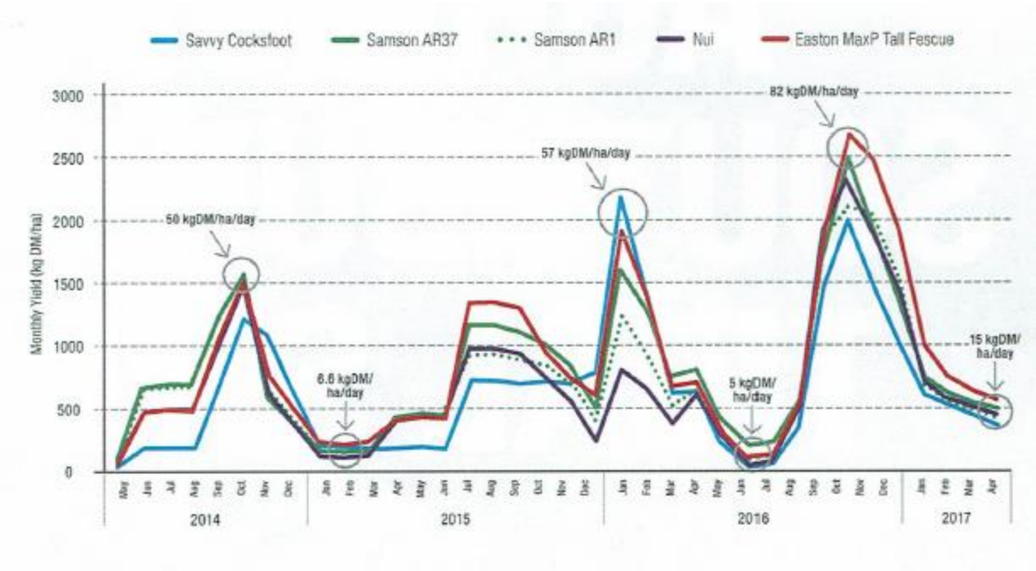


Figure 8: Monthly yield (kg DM/ha) of Savvy cocksfoot, Samson and Nui ryegrass, and Easton tall fescue over three and a half years at Southburn, New Zealand (Agricom 2017)

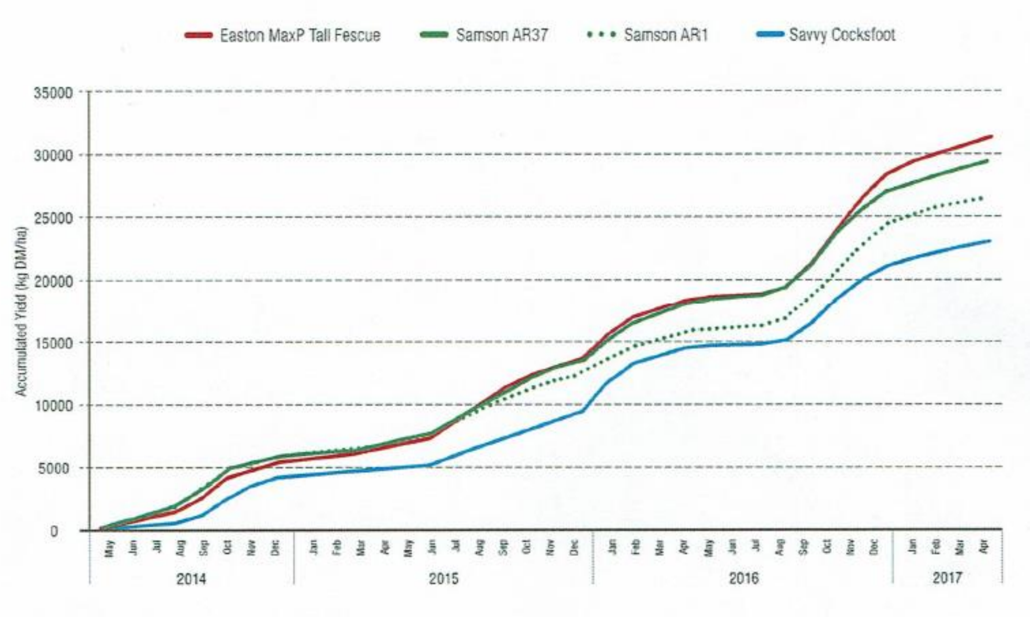


Figure 9 Accumulated yield (kg DM/ha of Savvy cocksfoot, Samson ryegrass and Easton tall fescue at Southburn, New Zealand over three and a half years (Agricom 2017)

In this trial the continental tall fescue produced the greatest amount of dry matter over the duration of the trial, however the value of having different species due to their slightly different growth habits is also apparent. Figure 8 shows that in years where the summer period is wet, cocksfoot will potentially out-produce tall fescue. However, this trend is reversed in wet springs, when ryegrass and tall fescue will outperform the cocksfoot. The data in Figure 8 also emphasises the variation in pasture growth throughout the year and across several years, further supporting the need to find suitable ways to fill the seasonal feed gap.

- **Lucerne**; An excellent case study on how lucerne can form the backbone of a grazing system was seen at the Avery family farm in New Zealand. Lucerne is extremely efficient at converting available water into quality forage with the deep taproot being a major asset. A pasture rotation has been designed to involve winter and spring feed options to further support the lucerne on the arable land. This pasture rotation features annual ryegrass, barley, rape and fodder beet. Professor Derrick Moot from Lincoln University in New Zealand has conducted extensive research into lucerne, and a paper from 2010 provides good evidence of the advantages of lucerne over other pasture species, as shown in Figure 10 below. Note the abbreviations refer to Cocksfoot (CF), Sub clover (Sub), Balansa clover (Bal), White clover (Wc), Caucasian Clover (Cc), Ryegrass (RG), and Lucerne (Luc). One of the biggest issues with Lucerne in a beef finishing system is the chance of bloat. Work is currently being undertaken in the USA into developing a Genetically modified non-bloating lucerne, which will soon be commercially available in the USA, however it may be quite some time before we see this GM variety being available in Australia.

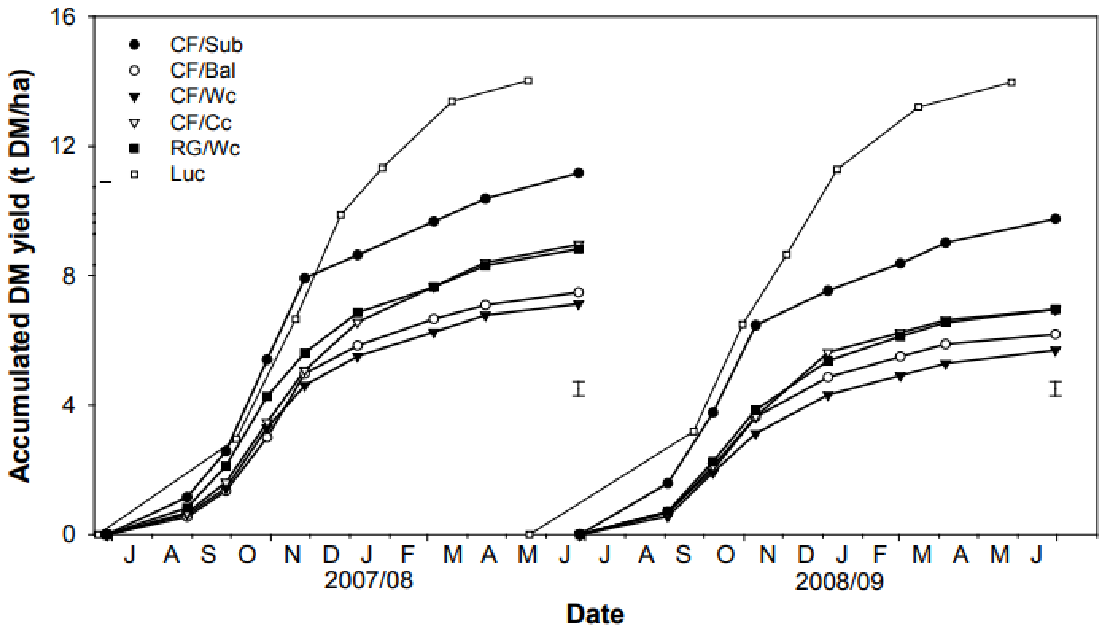


Figure 10: Total accumulated annual dry matter (DM) yield of six dryland pastures in 2007/08 (year 6) and 2008/09 (year 7) at Lincoln University. (Moot et all, 2010)

- **Sainfoin**; a highlight of visiting beef producers on the Canadian Prairies was learning about this plant species and seeing it under grazing conditions. Sainfoin is a perennial legume, which has both anthelmintic and non-bloating properties. This makes it somewhat unique when compared to other more common forage legumes such as clover and lucerne, which are renowned for causing bloat problems in cattle. Sainfoin is complimentary in pasture mixes with lucerne, and many Canadian beef producers were growing 50:50 lucerne:sainfoin pastures. This pasture may be a particularly valuable mixture for Australian systems if sainfoin can be managed to persist in Australian conditions. Sourcing sainfoin seed in Australia has also proven to be a challenge, with the author seeking to establish a trial plot of sainfoin on farm and being unable to locate commercial quantities of sainfoin seed anywhere in Australia in 2018.
- **Chicory**; in some instances, chicory has been promoted as an acid-tolerant alternative to lucerne. Chicory can be described as a short to medium term forage, with the typical lifespan of a sward being between one and six years. Key features of chicory include its high palatability, excellent livestock performance, good warm season production due to its deep tap root and it is also less likely to cause bloat in cattle when compared to clover or lucerne. Key management considerations with chicory include that it is highly responsive to applications of nitrogen, is susceptible to most broadleaf herbicides and it is susceptible to overgrazing. For these reasons, chicory is seen as a somewhat of a specialist forage and must be treated with a specific set of management guidelines. It can be used as a phase in a short term, high intensity crop-pasture rotation where weeds are effectively controlled in other phases of the rotation. Animal performance on chicory has been improved further with the addition of a source of fibre in the diet, often in the form of a grass such as ryegrass. An example of where chicory is being used as a specialist forage was in the Hawkes Bay region of New Zealand with James Hunter; James runs a lamb breeding and finishing operation and utilises chicory and clover to “supercharge” the system. The forage allows James to push his average lambing date later in spring, and then take advantage of the higher animal performance from chicory to finish lambs in a short period of time and achieve excellent quality carcasses and high yields.

- **Annual forages**; there are a multitude of annual C3 and C4 summer forage crops available which have a range of different features, all of which can best be described as opportunistic in comparison to deep-rooted perennials and which are best planted in regions receiving good summer rainfall or into a full soil moisture profile. Examples of C4 species include forage sorghum, Sudan grass, millet, maize, and legumes such as lab lab and cowpeas. Most of these species can produce a large volume of dry matter when the growth of perennial pastures has slowed significantly. Some key considerations for growing annual summer forages are soil temperature requirement at sowing (which for many species must be more than 16 degrees Celsius), nitrate and prussic acid poisoning, which varies between individual cultivars and seasonal conditions, and forage quality. Brown Mid Rib (BMR) varieties of sorghum and maize are regarded as having greater quality forage than standard (non-BMR) varieties. BMR grazing maize was seen growing on the South Island of New Zealand at the farm of Ryan O'Sullivan (2017 Scholar). This BMR maize was seen as a worthy alternative to more common forage sorghum varieties, due to the fact that the maize can be planted earlier at lower soil temperatures, hence allowing greater use of residual winter and spring soil moisture, and this maize does not have a Prussic acid risk. Forage brassicas also have potential in the system; examples include kale, forage rape, leafy turnips and swedes. Once again, soil moisture and summer rainfall will have a greater bearing on the success of the crop and they should be treated as an opportunity crop. The author is seeking to establish an on-farm summer forage trial to compare the suitability of annual forages over the 2018/19 summer period.
- **Tedera**; a new perennial legume which is being developed in Western Australia in a partnership with Meat & Livestock Australia and the Western Australia Department of Primary Industries and Regional Development. Tedera appears to have great promise as an alternative spring and summer grown plant which is well suited to the Mediterranean climate of Southern Australia, however is not well suited to areas prone to multiple severe frosts. In trials conducted with sheep in Western Australia, Tedera has outperformed lucerne in terms of animal performance and dry matter production. The plant is reported to be ready for commercial release in Australia by early 2019.

4.4. Autumn grazed pastures

Autumn can be the most challenging season for many producers in Southern Australia, with unreliable breaking rains to re-establish pasture growth, and soil moisture levels at their lowest in autumn, limiting the growth of even the most water efficient and deep-rooted plants such as lucerne. Whilst extensive travels across four continents did not reveal a silver bullet in the form of a specific plant species or farming system, several strategies were examined to assist producers in dealing with the autumn feed gap.

4.4.1 Stockpiling pasture

The concept of stockpiling pasture is becoming increasingly common in North America, where ranchers are amassing standing forage for grazing during the extreme winters experienced in parts of the USA and Canada. Stockpiling is essentially a cheaper way to conserve pasture when compared to making hay. The method is well explained in *Kick the Hay Habit* (Gerrish 2013), where ranchers learn to understand and measure their predicted feed demand for the specified feed gap period. Ranchers then prepare a pasture inventory and calculate how many hectares of pasture are required to be stockpiled based on daily pasture growth rates in the growing season. The quality of stockpiled pasture is highly variable and dependent on weather conditions, so generally it is not considered to be a finishing quality forage. It does however have the potential to fill an important role in the system. For a spring-calving system, calves are weaned in late summer or autumn, and pregnant non-lactating cows will successfully maintain body condition on stockpiled pastures through the autumn period. Likewise, in a trading enterprise where weaner cattle are purchased in autumn, significant gain can be had from purchasing weaner cattle earlier in the season before breaking rains when prices are lower due to less demand from re-stockers. These young cattle can be parked on stockpiled pastures at a low cost, ready to go when the season does break.

During a visit to a number of ranchers and consultants on the prairies of western Canada, including Matt Tees, Jim Bauer, Doug Wray, Graeme Finn and Nuffield scholar Daryl Chubb, the practice of swath grazing was examined. This is a method of stockpiling feed for the extremely cold Canadian winter, where pastures or annual crops such as oats are swathed (windrowed) prior to winter. The swathes are left to remain in the paddock and are essentially snap frozen at the onset of winter, preserving the feed quality. Beef animals are then given a set feed allocation (daily or twice weekly) and run behind an electric wire on the swathes during winter and follow along the swath under the snow to graze.

Phalaris is a common temperate perennial grass in Australian beef systems, however it was not seen in any other country visited during the Nuffield Scholarship. From the author's experience, Phalaris is seen as a suitable grass for stockpiling in spring during periods of excess growth, for use during the autumn period by non-lactating pregnant cows. Phalaris also responds very well to an extended rest period during spring which allows the plant to set seed and replenish root reserves. Following a heavy grazing in the autumn, in many cases phalaris has responded well with good regrowth generated from the stored root reserves, which is highly valuable for weaned calves in a dry autumn period.

4.4.2 Self-feeding silage pits

In contradiction to earlier comments regarding the high cost of supplementary feeds, one method of successfully using supplementary feed in a cost-effective way in New Zealand relied on self-feeding silage pits. The practice involves storing chopped silage (the lowest cost form of silage, compared to baled and wrapped) on specially designed feed pads. Animals are then introduced to the pad area, with an electrified wire running across the open face of the silage stack, as seen in Figure 11 below. The wire is shifted daily, allowing the animals access to a fresh section of silage. This method eliminates the extra machinery and labour costs associated with traditional ways of feeding chopped silage, including the need for a $25,000+ silage wagon. This practice is also a viable alternative to stockpiling pastures for young cattle, particularly as it can offer higher quality finishing feed.

Figure 11: Self feeding silage pit (Pinterest 2018)

4.4.3 Bale grazing

Another cost-effective method of utilising hay or baled silage, which was seen both in Canada and the UK, was bale grazing. This comes in several forms, but generally involves baling pasture in the traditional manner, but then storing the bales in one or two rows along the edge of the paddock from which they were cut. The paddock is often then planted to a forage crop such as kale, and strip grazed with a temporary electric fence. As the animals are provided their regular daily allowance of crop as the fence is moved, the fence also moves past another one or two bales which the animals are allowed to eat as they go. This effectively eliminates the need to store the bales in a shed and utilise machinery and labour to feed them out again. Figure 12 shows an example seen on a farm in South Western Scotland.

Figure 12: Bale grazing silage in a brassica crop

4.5. Winter grazing

4.5.1 Dual purpose crops

The concept of a dual-purpose crop is uncommon in many parts of the world. The most common reason for not grazing cereal crops in the UK was the risk of doing irreparable damage to the soil profile during the usual waterlogged winter. Other reasons in other grain growing regions of the world include a lack of suitable infrastructure for livestock, e.g. fencing and water in large cropping paddocks; fear of limiting grain yield and profits, shortness of the growing season, or the ability to grow other short-term specialist forage crops or pastures such as fodderbeet or perennial ryegrass. This resulted in a limited supply of suitable farms to visit to study dual purpose crops.

Oklahoma, USA, was one such place where the grazing of wheat is common, in a climate which is comparable to south eastern Australia. Tens of thousands of hectares of wheat are planted annually in Oklahoma, often in a wheat-on-wheat rotation in a full tillage system. Some of the more successful businesses were moving away from this system towards zero tillage and involving a greater variety of crops in the rotation. A common issue with grazing winter crops with cattle in a full tillage system is damage to the soil structure during wet conditions. Jimmy and Margaret-Anne Kinder from Walters, Oklahoma, were some of the first farmers in the state to move to a zero-tillage system, with the aim of increasing forage production from the grazing wheat and minimising damage to the soil from grazing in wet conditions. The primary reason for the move to zero tillage was simply to find the cheapest way to produce forage.

Essentially the beef animals on hand have to "pay" for the value of the grain to be potentially harvested from the crop. If the beef animals are not able to do this, then there is more value to be had by locking up the crop for grain production. The trigger point, or break-even point, for this grain or graze decision will change year on year depending on the input data, particularly the current beef and wheat prices.

These calculations are made in February which is the critical time by which if the crop is to be harvested for grain, cattle must be removed to avoid any negative impact on grain yield. In certain instances when the beef market conditions are in favour of grazing the crop out, some paddocks of wheat will be locked up and then sprayed out at approximately 10% heading with glyphosate and left as a standing haystack or stockpile. The premature termination of the crop preserves the feed quality of the crop at the time of spraying, allowing the grazing season to be extended. Other paddocks which are grazed out earlier may then be planted in spring with either a multi-species cover crop to boost soil organic carbon levels, or a summer grain crop such as sorghum. The point was made that whilst there have been benefits seen by growing the multi species cover crop, it did have a negative effect on the yield of the following wheat crop, and therefore the cover crop had to pay its own way by serving as a grazing crop itself.

As discussed earlier, timing is everything, and this certainly applies to the planting of both perennial pastures and annual forage crops. A delayed planting of an annual forage crop by one week can delay first grazing by several weeks, due to the rapid decline in soil temperature and day length as winter approaches. Dry planting is a viable option for grazing cereals once the trigger planting date occurs. A rainfall event of as little as 10 millimetres will usually be enough to germinate seed which is already in the ground, yet would not be enough to germinate seed planted post-rain. Another tactic which has proven to be successful in the experience of the author is in a compacted seed bed (i.e. coming out of perennial pasture) a very shallow cultivation prior to planting will significantly improve the germination of a crop on a light rain event, compared to direct drilling into a hard, dry seedbed.

Species selection is another decision which will depends on the specific requirements of the situation. The most common options available in Australia include oats, wheat, and more recently canola. Each species has its advantages and disadvantages as outlined below in Figure 13.

	Oats	**Wheat**	**Canola**	**Mixed-species Broadleaf**
Optimum Planting time	Feb/Mar	Mar/Apr	Feb/Mar/Apr	Mar/Apr
Weed control-Grass weeds	Poor	Good	Excellent	Excellent
Weed control-Broadleaf weeds	Good	Good	Moderate	Poor
Feed supply	Early	Mid/late	Mid	Late
Potential grain value ($/ha)	Low	High	High	Nil- high soil benefit
Animal health issues/requirements	Provide salt and magnesium	Provide salt and magnesium	Bloat & nitrate poisoning issues-provide roughage	Provide roughage and adequate transition

Figure 13: Dual purpose crop species comparison

Selecting a well-drained paddock with a free draining soil type is a good place to start. In many cases when coming out of a long-term perennial pasture a strategic cultivation is required to remedy soil compaction and to incorporate lime into the soil. This deep cultivation can become a handicap when a wet winter occurs, as animals will pug the soil and tread many plants into the ground. There is no easy way to deal with a wet winter when grazing crops, however a number of tactics can be put in place to reduce the negative effects.

- Run off paddock access- ensuring that cattle have access to a firm well drained pasture paddock as a run off paddock for wet conditions.
- Being proactive- removing stock from high risk paddocks ahead of forecast rainfall will allow a quicker return to grazing after rain than by leaving stock in during the rain and deciding to remove animals after damage has already been done.

- Early cultivation- if a paddock requires lime application and deep cultivation this can be completed the spring prior to an autumn planting of a cereal crop. A summer forage crop such as cowpeas or forage sorghum can be planted into the cultivated ground which serves as an extra source of feed over the summer months, as well as allowing grazing stock to then firm up the soil again (there is a low risk of waterlogging in summer) before terminating the summer forage and direct drilling the winter cereal.

After exploring several farming systems around the world, it appears that in the field of dual-purpose crops, the current level of technical knowledge available within Australia is second to none. Research conducted by a number of organisations including Meat & Livestock Australia, the Grains Research & Development Corporation (GRDC), and the New South Wales Department of Primary Industries is excellent and is a good place for farmers to find out more. In particular, a publication released by the GRDC titled “Grazing Cropped Land” is a recommended resource which is readily available.

In some areas of southern Australia, the climate lends itself to a unique method of spring sowing a dedicated winter variety of either canola or wheat as a dual-purpose crop. This crop remains vegetative and available for grazing from the time of sowing in November/December through until lock-up the following winter before being potentially harvested for grain approximately 12-14 months after planting. This is certainly seen as a profitable option where the climate will allow it, however the author has attempted it in two consecutive years with a suitable variety of winter wheat which did not survive a hot and dry late summer and autumn. Growers should exercise caution with this concept.

4.6. Spring grazing

4.6.1. The five R’s

When talking about his farming system in New Zealand, Fraser Avery broke the year down into three segments from a management point of view, which he called the three R’s. The first period is December to February, which he called the Risk period, where he ran a low stocking rate on the farm and played it safe. The second period is the Recovery period which extends from March through to August when the grass recovers from the typically dry summer period and begins to grow. The third R for Fraser Avery is the Revenue period, which is August through to December, which is when his animals do the majority of their growing and the main period for the farm to generate its annual income. This Revenue period is where the author has added in two additional R’s; the first is Rotation, which has already been discussed earlier in the report. The final R is Ryegrass, which on many of the farms visited was a major driver of farm productivity and revenue. Whilst in many parts of the Australian cropping belt ryegrass is a dirty word, in livestock circles its potential has not yet been fully realised. Perennial ryegrass may be described as a marginal option for many producers in the medium to high rainfall zone, and its persistence depends heavily on the intensity of the summer heat in any given region.

On the other hand, Italian and annual ryegrass has enormous potential as a one to three-year proposition for beef finishing systems. Some advantages of these short-term ryegrass varieties include their ease of establishment, relatively low seed cost per kg of dry matter produced, and excellent winter and spring growth. These species are also highly responsive to nitrogen, respond well to rotational grazing, and are highly palatable. Whilst some people may argue that everything grows well in spring, the beauty of ryegrass as a short-term forage crop is that it can carry a substantially higher stocking rate than other perennial pastures, allowing those perennial pastures to be rested and stockpiled for the autumn.

There are dozens of short-term ryegrass cultivars available on the market today, and every seed company’s glossy brochure will promote the benefits of one over another, meaning it can be quite a challenge for a producer to determine which cultivar is the best fit for their system. The author is planning to conduct an extensive demonstration plot on-farm in 2018 to compare over 20 short term ryegrass cultivars against a number of other temperate cool season forage species to examine the differences between each variety.

Festulolium is a hybrid cross between ryegrass (usually Italian) and fescue (usually meadow fescue), with the aim being to breed a grass which has the advantages of both species; the productivity and palatability of Italian ryegrass, and the root system and persistence of meadow fescue. The catch is that when crossing the two parent lines, there are so many variables which can be presented in the hybrid festulolium, resulting in a new plant line which is costly to breed, and is neither significantly different to an Italian ryegrass, or on the other end of the scale not significantly different to a meadow fescue. Plant breeding companies are continuing to work in developing new Festulolium lines, however it was not common to see it being grown on farm, and as yet has not taken off globally. Two lines of Festulolium are being included in demonstration plots on the authors family farm in 2018.

Conclusion

After outlining the features of a range of forage species, attention turns to how they can come together in a sequence to ultimately achieve the objectives set out in this report, in particular the final objective: to design a profitable, resilient and simple year-round forage based grazing system suited to beef cattle production. At this time, there remains a great deal of further trial work to be done in the form of demonstration plots to determine exactly which species will consistently perform as required. From there, decisions can be made on the amount of land to be allocated towards growing specific forage options to ensure an even supply of forage throughout the year. In other words, how many hectares of each different forage type are required across the farm to modify the seasonal feed curve to match animal demand.

Pending the results of further trial work, cocksfoot is seen to be the most suitable perennial grass species for summer production and may be used in conjunction with chicory as a reliable, low risk sward. Lucerne is also recommended to be included in the system, with the option to cut the first growth of lucerne in spring as chopped silage into a self-feeding silage pit for use during the autumn. This option helps to capitalise on the strong production of lucerne in spring, whilst avoiding a high bloat-risk period, and coincides with a period when large volumes of forage is available on short term ryegrass paddocks which can carry large numbers of stock.

Winter dual purpose wheat is recommended as the most suitable grazing cereal and is a recommended crop to recommence the crop cycle following a period of perennial pasture. This dual-purpose wheat is targeted at filling the feed curve during the winter months of June and July. Following the dual-purpose wheat, a short-term ryegrass is a suitable crop to plant, which will fill the feed curve behind the wheat, from August on through until early December. From December, chicory, lucerne and cocksfoot are aimed to provide forage through into January. An annual summer forage such as BMR maize can then take over through February and early March. Through autumn it is recommended that stockpiled phalaris pasture is utilised to feed non-lactating pregnant animals, whilst an opportunity exists to utilise a self-feeding silage pit (lucerne silage) to feed young stock. This sequence is represented in Figure 14 below.

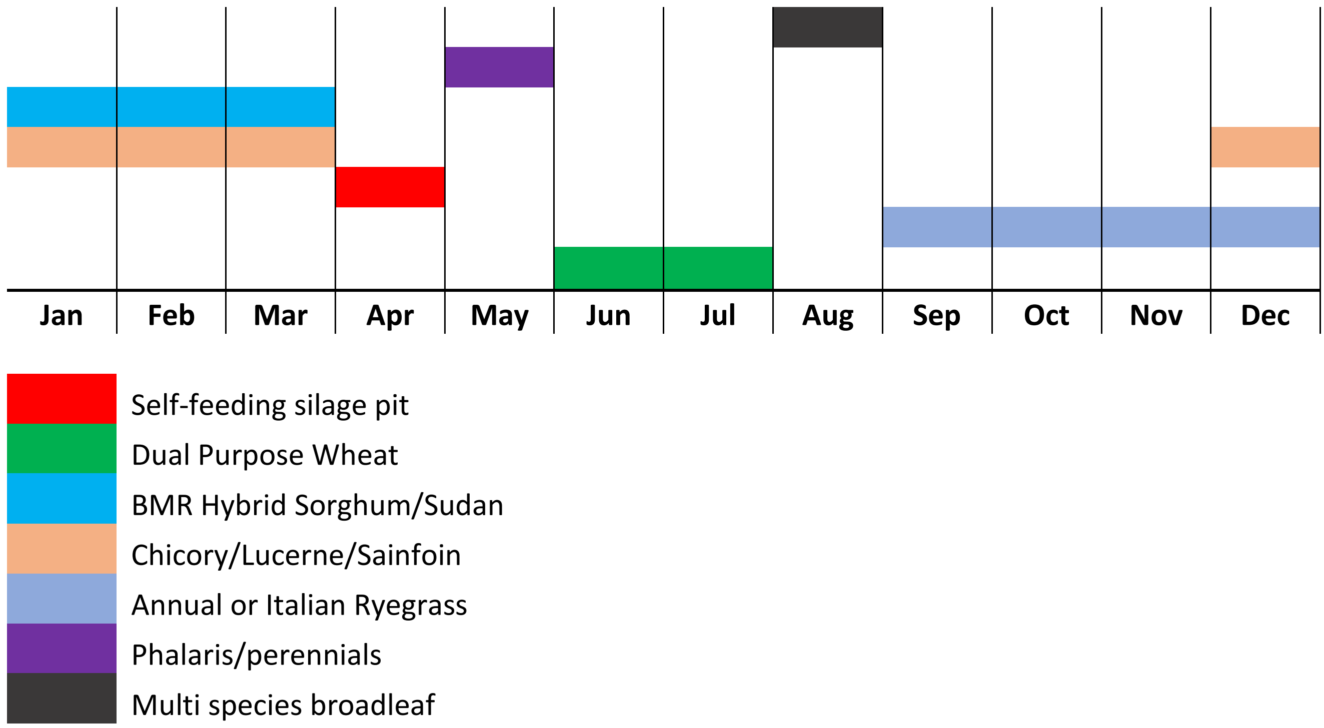


Figure 14: Proposed forage sequence for a finishing system

An alternative forage sequence for a spring calving beef breeding herd is proposed in figure 15 below:

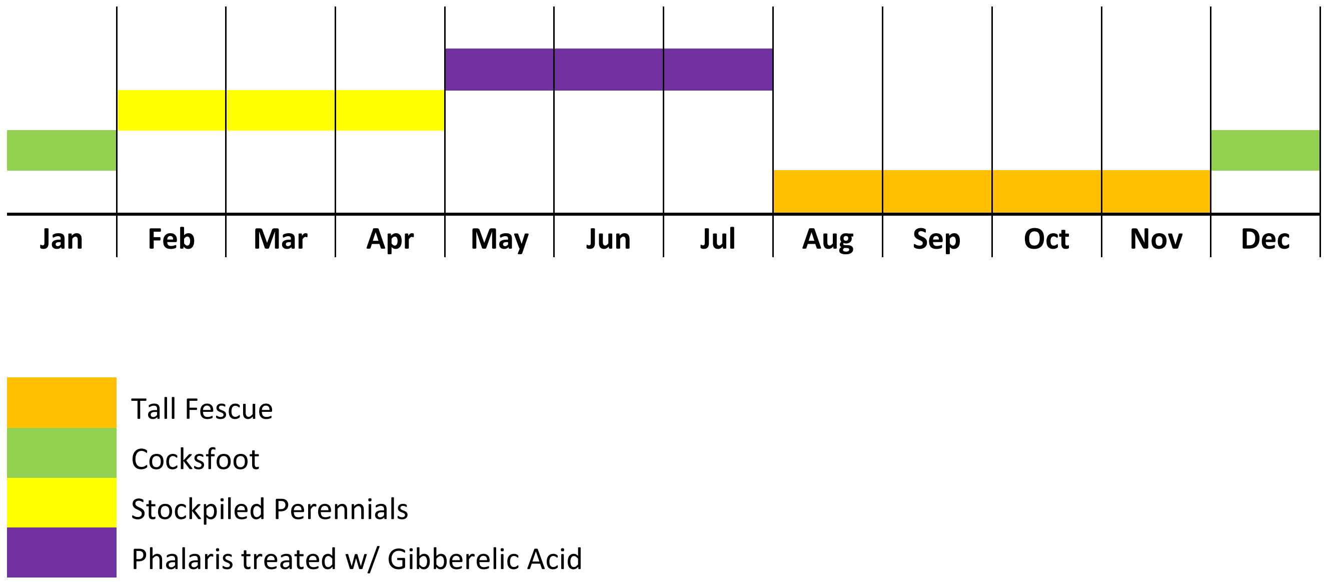


Figure 15: Proposed forage sequence for a spring calving breeder system

Several publications are available which provide greater detail into the design of a beef forage system and which have been valuable resources for the writing of this report. Jim Gerrish and

Allan Nation have several books discussing various aspects of pasture management which are available from the American Grazing Lands website or the Acres USA website. Doug Avery has also written an excellent book titled *The Resilient Farmer* which is highly recommended. Other valuable resources include *Grazing Cropped Land* from the GRDC, a number of scientific papers written by Prof. Derrick Moot from Lincoln University, and some simple feed budgeting and grazing management tools are available on the Meat & Livestock Australia website.

Recommendations

- Farm managers should be collecting and analysing specific data in relation to stocking rate and forage demand, as well as pasture growth and supply.
- Utilise sensor technology and software to ensure that the collection and analysis is simple and not laborious, and that the data is used to influence decision making.
- A systems approach is required to ensure the feed curve is matched to feed demand. A good place to start is by drawing the current seasonal feed curve and identify the feed gaps.
- Develop a flexible enterprise mix with the inclusion of trade stock.
- Use information collected to plan in advance and refine the timing of operations on farm. Set critical cut-off dates for key decisions such as adjustments to stocking rate, grazing rotations and crop planting.
- Paddock subdivision is useful to gain control over pasture supply and demand, and to intensify the system. Virtual fencing has huge potential to increase labour efficiency and improve rotational grazing management.
- Identify a pasture species, preferably a perennial, which is well-suited to the environment which can become the reliable centrepiece of the system and expand the system with other more specialist species to fill specific periods in the feed curve.
- Conduct small-scale on farm trials to determine which forage and pasture species are best suited to the operation.
- Treat pastures like crops; healthy soil is the essential ingredient to healthy pastures and in this respect pastures and forages should be treated intensively like a crop. Diverse pasture mixtures are a major part of maintaining healthy soil, and rotational grazing becomes a key factor in ensuring the persistence and productivity of diverse pasture swards.
- Enterprise analysis should be conducted on a per hectare basis, not per head. In other words, kilograms of beef produced per hectare have greater influence on profitability than kilograms gained per head.
- Stockpiling forage is a cost-effective method of conserving forage which can be used in both a breeding or trading enterprise. Mixed swards featuring perennial grasses

such as phalaris and legumes such as arrowleaf clover and lucerne or sainfoin are well suited to stockpiling and will respond exceptionally well post grazing.

- Dual purpose crops play a major role in filling the winter feed gap and also have been shown to significantly increase farm profitability

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Plain English Compendium Summary

Project Title:	Filling the Feed Gap; Designing a Profitable Forage-Based Beef Cattle System
Nuffield Australia Project No.:	1720
Scholar:	Stuart Tait Ridge End, 302 Burnt Yards Road, Mandurama New South Wales, 2792
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Objectives	• To investigate profitable means of filling the seasonal feed gap and eliminating the need for supplementary feeding in forage-based beef finishing systems. • To design a profitable, resilient and simple year-round forage based grazing system suited to beef cattle production
Background	The extensive use of supplementary feed to fill the seasonal feed gap in pasture-based beef systems in Southern Australia is seen as a significant inhibitor to profitability. Cost effective alternatives to fill the seasonal feed gap are explored.
Research	Study was undertaken throughout the USA, Canada, Ireland, Scotland, Wales, England, Uruguay, Argentina and New Zealand over 10 weeks of travel. Multiple beef and dairy farms were visited, along with research Institutions, Universities, consultants, conferences, books and interviews.
Outcomes	A number of recommendations are made for farmers and other involved in the beef industry. Increased collection and analysis of practical on-farm data, subdivision of grazing areas, a more intensive attitude towards pasture management in the same way grain crops are managed, and two examples of annual forage sequences are recommended.
Implications	This report informs readers of several practical factors which combine to create a simple and profitable beef forage system designed for Southern Australia, based on examples seen around the world.
Publications	Presentation at Nuffield Australia Conference, Melbourne, Australia, September 2018